SPECIFICATIONS

FOR

Omaha Public Schools – Blackburn High School
HVAC Improvements

Location:
Blackburn High School
2606 Hamilton St
Omaha, NE 68131

Owner:
Omaha Public Schools
District Operational Services
3215 Cuming Street
Omaha, Nebraska 68131-2024

Design Firm:
Advanced Engineering System
4630 Antelope Creek Road, Suite 200
Lincoln, NE 68506
P: (402) 488-0075
F: (402) 488-0272

AES's Project No. 25063
OPS Bid # 25017

May 20, 2025

Bid Invitation
Bid No. 25-017

TO BE CONSIDERED, BIDS MUST BE RECEIVED PRIOR TO THE DEADLINE
LATE BIDS WILL NOT BE ACCEPTED

The Board of Education for Douglas County School District 0001 (Omaha Public Schools) invites bids for:

OPS Blackburn VAVs & HVAC Control Replacement Project

RETURN TO:

Omaha Public Schools
District Operational Services
3215 Cuming St., Omaha, Nebraska 68131

IMPORTANT BID SUBMISSION INFORMATION AND DEADLINES

Bid Number	25-017
Date of Issuance of Bid	May 27, 2025
Prebid Meeting – **Mandatory**	June 4, 2025 @ 10:00 AM CT Blackburn Alternative Program 2606 Hamilton St, Omaha, NE 68131
Deadline for Submission of Questions	June 13, 2025
Bid Submission Deadline	June 24, 2025
Anticipated Bid Award & Board of Education Approval Timeline	July 14, 2025
Substantial Completion of Project	December 31, 2025

Question Submission Email Box Address	Questions_Clarifications_1@ops.org
Microsoft Teams Meeting Phone Number for Bid Opening	PM Verify with Purchasing 402-509-3892
Microsoft Team Conference ID for Bid Opening	PM Verify With Purchasing 402-509-3892
Address for in Person Bid Opening	District Operational Services Purchasing Division Omaha Public Schools 3215 Cuming Street Omaha, NE 68131

Bid 25-017

OPS Blackburn VAVs & HVAC Control Replacement Project

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1.0 BID INVITATION

Douglas County School District 0001 ("Omaha Public Schools"), ("OPS" or "District") invites qualified bidders to submit bids to furnish OPS with all labor, materials, tools, equipment, supplies, utility and transportation services and related work necessary for the design, supply and installation of Variable Air Volume ("VAV") boxes and upgrading the HVAC control system at Blackburn Alternative Program Facility ("Facility") located at 2606 Hamilton St, Omaha, NE 68131. The work includes, but is not limited to, (i) replacing all of the VAV boxes in the Facility, which include fan powered, dual duct and shut-off with reheat VAV boxes; (ii) upgrade the existing controls system to a new system with reusing end devices such as relays, actuators, pressure sensors, etc.; (iii) controls upgrade for the entire school including all existing and new HVAC equipment; (iv) testing, balancing and calibrating all new terminal units; (v) furnishing and installing associated HVAC, piping and electrical modifications; and (vi) all other work required under the Contract Documents in accordance with the Project Specifications and Drawings developed by the District and Advanced Engineering Systems, Inc. d/b/a AES Engineering ("AES Engineering") the Project Engineer (the foregoing work may collectively be referred to herein as "the Project" and may also be referred to as "the Work"). Work shall include working in an occupied and operating school. A more detailed description of the Work to be performed is located in Section 2.0, Contract Specifications, Section 3.0, Project Drawings and Project Specifications and in Exhibits A and B below. Bids must be completed on the bid form provided in the Bid Documents and submitted in accordance with the requirements stated in these Bid Documents. For purposes of this Bid, the term "Bid Documents" include the following documents: Bid Invitation, the Contract Specifications, the Project Drawings and Project Specifications, the Bid Submission Instructions and Requirements, the General Terms and Conditions, the Bid Form and Signature Page, Exhibits A, Project Specifications and Exhibit B Project Drawings and any Addenda issued prior to bid opening. The Bid Documents are not complete unless all of these documents are included. Bidders should review all the Bid Documents carefully before submitting a bid proposal since these Bid Documents, along with other documents that are referred to in the Bid Documents, will be incorporated into and will become a part of any Purchase Order or Contract (as hereinafter defined) between OPS and a successful bidder for the Work.

Please note the mandatory pre-bid meeting requirement for all potential bidders. See Section 4.4 below.

Submit bids in a sealed opaque envelope or container clearly marked on the exterior of the envelope or container with the information listed below:

BID No. 25-017, **OPS Blackburn VAVs & HVAC Control Replacement Project**

Address for the submission of bids:

Omaha Public Schools
District Operational Services
3215 Cuming St.
Omaha, NE 68131

Hand-delivered bids shall be brought to the Security Desk at the East Entrance on the Ground Floor of the Teacher Administrative Center (TAC) at the above address.

2.0 CONTRACT SPECIFICATIONS

2.1 SPECIFICATIONS & SCOPE OF WORK

The Work called for in these Bid Documents includes the design, furnishing and installation of the VAVs & HVAC Control Replacement at Blackburn Alternative Program Facility, located at 2606

Hamilton St, Omaha, NE 68131. The Work includes, but is not limited to all mechanical, electric, control, low voltage wiring, pathways, testing and balancing, pressure sensors, calibrating all new terminal units, electrical modifications and related Work described more fully in the Project Drawings and the Project Specifications..

In general, all materials and equipment to be furnished by Contractor must be of good quality, new and unused, undamaged, and shall be constructed and installed as required in the Contract Documents and of the types of equipment and materials as specified.

It is the Contractor's responsibility to protect existing construction. In addition, daily removal of debris and repair of any damage due to work under this Contract is considered within the scope of Work and is the responsibility of the Contractor.

Contractor shall be responsible for the performance of all of the Work for the Project. Unless specifically prohibited by the Contract Documents, Contractor may retain qualified and responsible subcontractors for the performance of parts of the Work. Such subcontractors must be reasonably acceptable to the District. Contractor shall be fully responsible to District for all acts and omissions of the Contractor's subcontractors, suppliers, and other individuals or entities performing or furnishing any of the Work provided by or under the control of the Contractor, just as Contractor is responsible for Contractor's own acts and omissions. No acceptance by District of any such subcontractor, supplier, or other individual or entity, whether initially or as a replacement, shall constitute a waiver of the right of District to the completion of the Work in accordance with this Contract Documents. Contractor shall be solely responsible for scheduling and coordinating the Work of subcontractors, suppliers, and all other individuals or entities performing or furnishing any of the Work, which are under the control of Contractor.

All Work must be done in accordance with best trade practices using qualified workmen. All Work shall be performed in a manner that does not void any manufacturer's warranty.

All engineering work and plan preparations for shop drawings and other Contractor submittals shall be the responsibility of the Contractor, who shall utilize qualified and licensed engineers for such work.

2.2 WORK HOURS AND WORK DAYS

With respect to Work in or in connection with OPS occupied facilities, it is expected that all Work will be performed during normal working hours (6:30 am – 5:00 pm CT) on regular working days (Monday-Friday) exclusive of District observed holidays. Should the Contractor desire to work at other times, advance requests shall be made to the project manager so that the areas can be made available. OPS personnel must be on hand at any time work is in progress at such an occupied location.

2.3 CONTRACTOR EXPERIENCE AND PROJECT STAFFING

The District requires that the Contractor for this Project have a minimum of five (5) years' experience with commercial HVAC systems. Contractor and its personnel shall be duly licensed by the City of Omaha to perform the mechanical and electrical installation work required by the Contract with the District.

All work must be done in accordance with best trade practices using qualified workers. Qualified workers shall mean at least one (1) experienced journeyman for every two (2) workers on the job site. There shall be a minimum of three (3) workers from start of Project to completion. At all times, at least one of the Contractor's work crew must be fluent in English and able to communicate in the language of the remaining crew members.

2.4 PROJECT COMMENCEMENT, COMPLETION DATES AND LIQUIDATED DAMAGES

The performance of the Work shall commence upon receipt by Contractor of written notice to proceed from District. A notice to proceed will not be issued prior to execution of the Contract between the District and the Contractor, and in any event, not prior to July 15, 2025. Moreover, the District will not issue a notice to proceed until Contractor and the District have executed the Contract for the Project and the Contractor has furnished District with an insurance certificate and a performance, labor, and material bond complying with the requirements of the Contract Documents.

Substantial Completion of the work shall be achieved not later than December 31, 2025. Final Completion shall be achieved not later than thirty (30) days after Substantial Completion is achieved.

If Contractor does not achieve Substantial Completion by the date set forth in this Section, as may have been extended by Change Order, Contractor shall pay to District as liquidated damages the sum of $500.00 per day for each calendar day after the day set for Substantial Completion that Substantial Completion has not been achieved. See Section 5.32 below.

2.5 ASBESTOS

Asbestos containing materials (ACM) *have NOT been* found at Blackburn Alternative Program in the proposed work areas. It is the Contractor's responsibility to review and study the information that may relate to asbestos-bearing material with which the Contractor may come into contact. A document describing the general location and characteristics of this material is available in the building office or through the Asbestos Program Coordinator's office at 4041 North 72nd Street, Omaha, Nebraska 68134 for your review. During this Project, should any suspected material be found, Contractor should stop work in the area immediately and contact this office at 531-299-0180.

2.6 ASBESTOS DAILY AWARENESS

Contractor shall be responsible for coordinating a central sign-in location at the facility where the Project is located for enforcement of the District’s requirements of the asbestos material awareness program. Each employee, subcontractor employee and other individuals under contract with the Contractor shall be advised of locations of any hazardous material at the facility. This sign-in certificate must be submitted weekly and prior to final closeout on the Project.

2.7 ASBESTOS REMOVAL, NOTIFICATION

All known and accessible asbestos-containing material has been identified for this Project area by the District’s Environmental Division. In the event Contractor encounters suspect asbestos-containing or other hazardous materials at the Project site, Contractor shall stop work immediately in the suspected contaminated area and contact the District’s Environmental Division at 531-299-0180.

2.8 EQUIPMENT AND INSTALLATION REQUIREMENTS

Contractor will be required to perform all Work and supply any and all equipment and accessories described in the Contract Documents or that are necessary for completion of the Project. This includes supplying accessories such as, wiring and electrical connections and labeling as required by the Contract Documents, or reasonably inferable therefrom, so that the equipment being supplied by Contractor will be fully operational in this facility.

Work at the Project site shall start within forty-eight (48) hours of delivery of equipment, provided notice to proceed has previously been given by the District.

2.9 UNIT PRICES

During the course of the performance of the Work, the Contractor may recommend to the District, or the District may direct, that certain control valves, control damper actuators, duct temperature sensors or water temperature sensors be replaced. If the District directs such replacement, or the District approves the Contractors recommendation for replacement, Contractor shall replace each such item of equipment with the appropriate replacement equipment that is included in the list of Unit Price equipment in the Contractor's bid proposal. All such equipment installed shall be of good quality, new and unused and undamaged and the equipment installed must be the same manufacturer and model listed in the Contractor's bid proposal. The unit price for each such item of equipment shall be the unit price that was included in the Contractor's bid proposal for that item and shall be the total cost to OPS for the Work specified. The unit price for each item of equipment included in the Contractor's bid proposal shall include all installation costs for the equipment, including all labor, materials, tools, equipment and associated wiring and all programming, together with all insurance costs, delivery costs, duties, surcharges, tariffs and brokerage costs, and no other amount shall be charged to OPS for such Work. Any installation of unit priced equipment shall be reflected in a Change Order approved by OPS. OPS does not guarantee that any particular number of unit priced items of equipment will be required for the Work, or that any unit priced items of equipment will in fact be installed.

2.11 WARRANTIES

Contractor's one (1) year warranty set forth in the General Terms and Conditions that are a part of the Contract Documents shall run for a period of one (1) year from Substantial Completion. Materials must be installed in a manner that does not void or limit any manufacturer's warranty for such materials. Prior to final completion, Contractor will take any corrective measures and work to assure that the full manufacturer's warranty will apply to this Project.

2.12 MATERIALS AND EQUIPMENT TO BE FURNISHED

The specifications for any required materials and equipment are contained in the Project Drawings and Project Specifications, prepared by AES Engineering and which are identified in Exhibits A and B of the Bid Documents and which are a part of the Bid Documents and will be a part of the Contract Documents as hereinafter defined.

3.0 PROJECT DRAWINGS AND SPECIFICATIONS

The Project Drawings and Project Specifications identified below have been prepared by AES Engineering, are a part of the Bid Documents and will become part of the Contract Documents comprising the Contract between the Contractor and OPS. These Plans and Specifications are described as follows.

3.1 PROJECT SPECIFICATIONS

The Project Manual with the Project Specifications, as prepared by AES Engineering, include the following construction Divisions and reports and all such Project Specifications are included in the Bid Documents and will be included in the Contract Documents.

Project Specifications:
Table of Contents
Division 00 – Procurement and Contracting Requirements
Division 01 – General Requirements
Division 23 – Heating Ventilating and Air Conditioning

3.2 PROJECT DRAWINGS

A Schedule of Drawings that have been prepared by AES Engineering for the Project are listed on Exhibit B, and those Drawings are included in the Bid Documents and will also be included in the Contract Documents.

Drawing Sheets:
Index Sheet
M0.0- HVAC Zoning Plan, Notes and Symbols
MD1.1- First Floor Mechanical Demo Plan – Area A
MD1.2- First Floor Mechanical Demo Plan – Area B
MD1.3- First Floor Mechanical Demo Plan – Area C
MD2.1- First Floor Mechanical Demo Plan – Area D
MD2.2- First Floor Mechanical Demo Plan – Area E
M1.1- First Floor Mechanical Plan – Area A
M1.2- First Floor Mechanical Plan – Area B
M1.3- First Floor Mechanical Plan – Area C
M2.1- Second Floor Mechanical Plan – Area D
M2.2- Second Floor Mechanical Plan – Area E
MD 3.1- Mechanical Details and Schedules

4.0 BID SUBMISSION INSTRUCTIONS AND REQUIREMENTS

4.1 GENERAL

To be considered, bids must be submitted in accordance with the bid instructions set forth in these Bid Documents. Failure to comply with the requirements of these bid instructions may result in the rejection of the bidder's bid proposal.

The term "Bid Documents" is defined in Section 1.0 of the Invitation to Bidders. The Bid Documents are incomplete if they do not contain all of the Bid Documents identified in that Section. Bids must be prepared on the unaltered bid form included in the Bid Documents with all required information provided and submitted in a sealed opaque envelope or container with the bid name, bid number and the date and time of the deadline for submitting bids noted on the exterior of the envelope or container. DO NOT SUBMIT BIDS ON ANY OTHER FORM. Bids must also include the original bid bond and all attachments required by the Bid Documents. E-mail, facsimile or telephone bids will not be accepted. Any incomplete bid or bid not complying with the Bid Documents may be rejected by the District.

Bids are due at 2:00 PM Central time on the due date specified in the Cover Page at the Teacher Administrative Center, 3215 Cuming Street, Omaha, Nebraska 68131. Hand-delivered bids shall be brought to the Security Desk at the East Entrance on the Ground Floor of the Teacher Administrative Center. Any bid received after the deadline for submission of bids will not be considered and will be rejected and returned to the bidder unopened. The risk of delivery rests solely on the bidder. The time stamp on the District's timeclock in the District Operational Services' offices will be the official clock utilized to determine the close of the time for submission of bids.

4.2 DISTRICT'S RIGHT

The District reserves the right to accept or reject any or all bids or any part thereof and to waive any and all technicalities and irregularities and award the Contract based on its determination of the best interests of the District.

4.3 PROJECT DRAWINGS AND SPECIFICATIONS

Bona fide bidders may inspect and obtain copies of the Project Manual with the Specifications for the Project, and the Project Drawings, as identified in Exhibits A and B of the Bid Documents, at any of the locations specified in the Bid Advertisement. Plans and Specifications are also available for download on the OPS Purchasing Department website.

4.4 MANDATORY PRE-BID MEETING

OPS will conduct a mandatory pre-bid meeting for interested bidders at Blackburn Alternative Program 2606 Hamilton St, Omaha, NE 68131, on June 4, 2025, at 10:00 AM CT. All attendees are required to sign-in at that time, and only those who attend the pre-bid meeting will be allowed to submit a bid. Proposals received from bidders not attending the pre-bid meeting will be returned unopened. Questions may be asked at the pre-bid meeting. However, such questions and the answers given will not be transcribed or transmitted to the other potential bidders.

4.5 BID QUESTIONS

Any questions or requests for interpretation of these Bid Documents must be submitted in writing by e-mail to the question submission box at the email address included on the Cover Page of the Bid Documents, by 2:00 p.m. CT on or before the deadline for submission of questions. The subject line of the email must include at a minimum the Bid Name and Bid Number of the Project. Both the question submission box address and the deadline are listed on the Cover Page. Answers to questions will be posted on the OPS Purchasing website, the plan house websites in which the District has been requested plans be made available, and provided to all attendees who signed in at the Project pre-bid meeting, without indicating which Bidder submitted the question. The communications requirements have been established by the District to ensure a fair and equitable process for all potential respondents. The email address listed on the Bid Cover Page for questions is the only authorized location and representative of the District who can respond to questions regarding this bid. Questions submitted in any other form, including by hard copy, facsimile and telephone, and questions submitted to an email address other than the one indicated in these Bid Documents will NOT be answered. Any attempt to communicate with or contact any Board Member, employee, or consultant of the District of in any manner having to do with any aspect of this bid may result in the disqualification of the Firm as a potential supplier.

4.6 BID BOND

An original certified check or cashier's check payable to the Board of Education or satisfactory original Bid Bond executed by the bidder and acceptable sureties in an amount equal to five percent (5%) of the amount of the bid shall be submitted with each bid (the certified or cashier's check and the bid bond may sometimes be collectively or individually referred to in these Bid Documents as the "Bid Security"). If an original cashier's or certified check or an original signed Bid Bond (not a photocopy) as required by this Section is not submitted the District with the bidder's bid submission in a sealed opaque envelope or container by the bid submission deadline, the bid will not be considered. To be valid, the Bid Bond submitted must have original signatures of both the bidder and the surety on the Bond, and if signed by an attorney-in-fact for the surety, a valid power of attorney from the surety must be attached to the Bid Bond. The Bid Security will be retained as liquidated damages in case the bidder awarded the Contract fails to furnish the required Performance, Labor and Material Payment Bond, insurance certificate, or sign the Contract within ten (10) days after presentation of the Contract to the successful bidder. If original Bid Security as required by this Section is not received by the District with bidder's bid proposal by the deadline for submission of bids, is submitted in any other manner, or is submitted to an address other than the one indicated in these Bid Documents, the bid by bidder failing to properly submit the Bid Security will NOT be considered, even if the bid was otherwise properly submitted. The bidder shall have all risk of failed or late delivery of the Bid Security.

4.7 BID PREPARATION

All bids must be completed and submitted on the unaltered OPS bid form that is a part of the Bid Documents. DO NOT SUBMIT BIDS ON ANY OTHER FORM. If a new bid form is issued by OPS by an Addendum to the Bid Documents, the new bid form must be used for bid submission, and using an earlier version of the bid form may result in the bid being rejected. Unless specifically allowed in the Bid Documents, only one bid form may be submitted by any bidder. All required blanks on the bid form must be completed and be initialed and dated where indicated and the final page of the bid form must be signed by an authorized representative of the bidder. All attachments and required information requested in the bid form must be furnished, together with the Bid Bond. Bids are to be submitted to the location specified in the Bid Documents by the time and date indicated in the Bid Documents. Bids are to be submitted in a sealed opaque envelope or container addressed as specified on the Invitation to Bid with the required notation on the exterior of the sealed envelope or container. The amount bid shall be the total cost to OPS for the successful bidder awarded the bid to provide and furnish all labor, materials, equipment, tools, expendable equipment and all utility and transportation services necessary to perform and complete in a workmanlike manner all of the Work required by the bid Documents. Bids that attempt to change, modify or add additional terms and conditions to the Bid Documents by conditioning a bid response upon the acceptance by OPS of Contract terms attached to a bid response or referencing in a bid response certain Contract terms on a web site shall be considered non-complying bids by OPS and the bid may be rejected by OPS.

4.8 BID SUBMITTAL

To be considered, one (1) copy the bidder's proposal prepared in compliance with the requirements of the Bid Documents must be submitted to the District by the proposal deadline listed on the Cover Page. The amount bid shall be the total cost to OPS for the Work specified, inclusive of all the labor, materials, equipment, tools, supplies and services enumerated in the Bid Documents, together with all insurance costs, delivery costs, duties, surcharges, tariffs and brokerage costs and no additional amount will be paid by OPS to the successful bidder for the Work. No bidder will be allowed to offer more than one price. Bids that attempt to change, modify or add additional terms and conditions to the Bid Documents will be rejected by OPS. Bids must be signed by an authorized signatory for bidder and initialed and dated where indicated. Bids and Bid Security must be submitted in hard copy to the address specified in the Bid Documents by the time and date indicated in the Bid Documents. The time stamp on the Purchasing Department time clock will be the official clock utilized to determine the time for the close of submissions. Bids may be submitted either in person or by mail or courier to the address shown on the cover page. All submitted bids must comply with the following requirements:

- Bidder must include the Bid Proposal with the completed Signature page.
- Bid Security equal to 5% of the bidder's bid amount as previously described in Section 4.6.
- The bid must be submitted in hard copy with the bid title and bid number written on the exterior of the envelope or container containing the bid.
- All required attachments must be submitted with the bid proposal.

4.9 BID ATTACHMENTS

Bidders shall include with their bid responses the following attachments: (i) summary of the manufacturer's warranty terms for the materials and equipment the bidder is proposing to furnish; and (ii) the specifications for the Contractor furnished materials and equipment specified in the Project Drawings and in the Project Specifications that the bidder is proposing to furnish.

4.10 BID SUBMISSION DEADLINE

Bids are due by 2:00 p.m. Central time on the due date specified on the Cover Page and in the Bid Documents. Bids received after 2:00 p.m. Central time on the due date are considered late and will be returned unopened. OPS is not responsible for ANY late bids due to failure or delay in mail delivery. The bid must be received by the time and date indicated on the bid document. The risk of delivery rests solely on the bidder. Late bids will not be accepted. The time stamp maintained by District Operational Services shall be the official clock for determining when the time for submission of bids has closed.

4.11 WITHDRAWALS AND RESUBMISSIONS

Withdrawal of a bid may be made by a bidder any time prior to 2:00 p.m. Central time on the bid due date. A withdrawal may only be done by the bidder's written notification delivered to the same address where the bid was originally submitted, with the following notation on the exterior of the envelope containing the withdrawal: "Withdrawal of Bid" including the Bid number and the Bid title. The withdrawal notification must be received by the OPS Purchasing Division prior to the date and time of the bid submission deadline. An attempted withdrawal in any other form, including email, facsimile, telephone or oral withdrawal request will not be honored. An addendum or bid modification in lieu of a withdrawal is NOT acceptable and will be rejected. If properly withdrawn, a bid may be resubmitted in accordance with the Bid Documents so long as it is re-submitted prior to the deadline for submission of bids. All bids submitted and not withdrawn as specified in the Bid Documents shall remain open and be subject to acceptance for ninety (90) days after the bid due date and may not be withdrawn prior to the expiration of such 90-day period.

4.12 OPENING OF BIDS OR PROPOSALS

Bids will be opened and read aloud in public at the Omaha Public Schools Teacher Administrative Center, District Operational Services, 3215 Cuming St, Omaha, Nebraska 68131, immediately following the bid submission deadline stated on the Bid Document Cover Page. Those submitting bids can attend in person or remotely join the opening by accessing Microsoft Teams meeting at 1 402-509-3892 within the United States Phone Conference ID is listed on the Bid Cover Page. If attending in person, please arrive at the security desk at least 10 minutes prior to the 2:00 PM CT deadline.

4.13 BID TABULATIONS

Notes may be taken at the public reading of the bids at the specified time and date of the opening, or a personal inspection may be made of the bids after award has been made and documents are placed in central files in the Purchasing Division offices. In lieu of a visit, copies of the bid tabulations are available. The cost for a bid tabulation copy is $5.00 for any tabulation up to 20 pages in length. There is an additional charge of $.25 for each page in excess of 20 pages. Make checks payable to Douglas County School District 0001. Bidders may include a request for a bid tabulation copy with its bid response or may contact the OPS buyer to make a request. The buyer will notify the bidder regarding the cost of the bid tabulation once it is known.

4.14 BIDDER REPRESENTATION

In submitting a proposal, the Contractor represents that it has read the Bid Documents, that its bid is submitted in accordance therewith, that the bidder is familiar with the local conditions that may affect the bid and the performance of the Work by the successful bidder and that the bidder has all required governmental licenses to perform the type of Work required.

4.15 COLLUSIVE BIDDING

The bidder's submission of its bid response is the bidder's representation and guarantee to OPS that the prices quoted have been arrived at without collusion with any other eligible bidders and without an attempt to preclude OPS from obtaining the lowest possible competitive price, influencing the prices quoted by any other eligible bidder or discouraging other potential bidders from bidding.

4.16 POST-BID EVALUATIONS

Prior to recommendation to the Board of Education for the bid award, District will review the apparent low bidder's qualifications and credible experience in similar projects to assure that the bidder meets the experience required by the District in the Contract Specifications that are a part of the Bid Documents. As part of that evaluation, the District reserves the right to ask any bidder to provide references of companies that contracted with Contractor for similar projects, including the following information: Company Name(s), Contact Name, Phone Number, and Email Address.

4.17 EVALUATION OF UNIT PRICES

Included in the Bid Form is a requirement for the bidder to include unit prices for certain types of equipment. Bidders must furnish all of the information required in the bid form for the unit priced equipment. Evaluation of the bidder's bid will include the cost of the unit priced equipment as reflected in the Bidder's bid. This will be done by totaling the extended price amount for each item of unit priced equipment determined using the estimated quantities of each item of unit priced equipment listed by OPS in the bid form and then adding that amount to the bidder's lump sum base bid stated on the first page of the bidder's bid form. The quantity of each item of unit priced equipment used to determine the extended price is a good faith estimate by OPS of the amount of each type of unit priced equipment that may be required, but the amount that is actually installed is not guaranteed and may be greater or less than the quantity stated in the bid form. See Section 2.9 for the requirements for unit priced equipment.

4.18 BID AWARD

OPS reserves the right to reject any or all bids or any part thereof and to waive any and all technicalities and irregularities. This is an all or nothing bid, and the bid will only be awarded to one bidder. The OPS Board of Education must approve all bid awards and contracts of $50,000.00 or more. Except due to a holiday or an extenuating circumstance, the Board generally meets the first and third Monday of each month for approval of bids and purchases. Approval or award of a bid by OPS or its Board of Education does NOT constitute a contract between OPS and the bidder and no contract shall be deemed created, nor shall OPS be deemed obligated in any manner to bidder, until such time as the bidder furnishes the required Performance, Labor and Material Payment Bond, insurance certificate and an Agreement is signed by Contractor and OPS, or a Purchase Order is issued by OPS if no separate Contract is required. OPS will either sign an Agreement with or issue an official Purchase Order to the successful bidder which, together with the other Contract Documents incorporated therein, will constitute the Contract with OPS for the construction of the Project as specified in the Agreement or Purchase Order and will incorporate by reference into the Agreement or Purchase Order the Contract Documents (defined in the General Terms and Conditions, in Section 5.1 below). If an Agreement is to be executed, OPS will submit to the successful bidder after the bid award the Agreement form that will be utilized by the parties.

5.0 GENERAL TERMS AND CONDITIONS

5.1 GENERAL

The term “Contract Documents”, as used herein, means those documents that together form the Contract or Agreement between OPS and that consist of the following: the Agreement between OPS and the Contractor, all of the Bid Documents, the Information to Bidders (Section 1.0), the Contract Specifications (Sections 2.0 to 2.12, inclusive), the Project Drawings and Specifications (Sections 3.0 to 3.2, inclusive), the Bid Submission Instructions and Requirements (Sections 4.0 to 4.18), the General Terms and Conditions (Sections 5.0 to 5.38, inclusive), the Bid Form, the form of the Performance, Labor, and Material Bond, Exhibits A and B, any Addenda issued by OPS, Contractor’s completed Bid Form including all attachments, and any subsequent modifications. The Contract Documents are incorporated by reference into the Contract between OPS and Contractor and are a part of that Agreement. In the event of any conflict between the Contractor’s completed Bid Form and the other Contract Document, the other Contract Documents shall control. The term “Contractor” as used herein, means the successful bidder that contracts with the District to furnish the Work being bid.

All work to be performed by Contractor shall be performed in a good and workmanlike manner and in conformance with the requirements of the Contract Documents.

The Contract Specifications in Section 2.0 and the Project Drawings (Exhibit B) and Project Specifications (Exhibit A) prepared by AES Engineering and referred to in Section 3.0 are all incorporated into the Contract Documents, provide the minimum requirements for materials, workmanship, construction, and finish. In general, all equipment to be furnished must be of good quality, new, unused, in good condition and undamaged and shall be constructed and installed as specified and of types of equipment and material as specified. Materials of equal or better quality by another manufacturer may be acceptable but only if submitted to the District in advance as a permitted alternate and approved by the District.

5.2 CONTRACTOR'S RESPONSIBILITY

Prior to commencing work, Contractor shall furnish to the District the bond and insurance certificates required by the Contract Documents. It shall be the responsibility of the Contractor to review and understand the Project Drawings and Project Specifications, to check the Project Drawings and Project Specifications carefully to ensure accurate fit of its particular items of equipment, and to field verify all on-job dimensions.

Contractor and District personnel will also meet for a pre-construction meeting and survey. The survey shall document the existing condition of interior finishes and existing spaces, sidewalks, driveways, doorways, windows, etc. adjacent to areas of Work. It shall also identify acceptable dumpster locations, construction parking, and Contractor-furnished watering stations and locations for temporary sanitary facilities for use by construction personnel.

Projects involving asbestos containing materials require Contractor to meet with the District’s Environmental Division at (531-299-0180) prior to starting work to ensure compliance with State of Nebraska Asbestos Control Program Regulations.

Contractor shall have all assigned workers of Contractor and any subcontractors be approved through OneSource and provide documentation of such to the District. All assigned Contractor and subcontractor employees shall wear proper identification badges as provided by OneSource.

Contractor shall protect all existing construction. Repair of any damage caused due to work under the Contract Documents is the responsibility of the Contractor and shall be promptly completed as such damages arise. Similarly, Contractor shall repair any damage to the property of the District caused by Contractor or any subcontractor of Contractor.

Contractor and each subcontractor shall always enforce strict discipline and good order among employees and shall not employ on the work site any unfit person or anyone not skilled in the work assigned. Clothing shall not depict profane or vulgar images, words, or phrases unsuitable for students or staff. The District strictly prohibits the illegal use of drugs, alcohol consumption, and the possession of permitted and/or non-permitted firearms within the boundaries of District property.

Contractor will provide at its expense temporary sanitary facilities for use by construction personnel. District restrooms shall not be used by construction personnel.

5.3 CHANGES IN THE WORK

No change in the work required shall be made unless pursuant to a written change order that is approved by the District. No claim for an increase in the amount to be paid to Contractor or any extension of time to complete the Work shall be valid unless allowed by such approved change order.

5.4 LABOR PRACTICES

It shall be the Contractor's responsibility to prevent any labor disputes due to Contractor's actions at the job site. In this regard, Contractor shall adhere to the following minimal guidelines to avoid labor disputes.

5.4.1 Become familiar with labor practices in existence at the job site as established by the existing contractors, and ensure that these practices are in place and enforced at all times during the performance of the work specified in these General Conditions.

5.4.2 Use experienced, established laborers and contractors for any work pertinent to the transportation, loading, unloading, distribution, uncrating and installation of all equipment, accessories and materials necessary for the performance of the work specified in these General Conditions.

5.5 NON-DISCRIMINATION

OPS does not discriminate on the basis of race, color, national origin, religion, sex (including pregnancy), marital status, sexual orientation, disability, age, genetic information, gender identity, gender expression, citizenship status, veteran status, political affiliation or economic status in its programs, activities and employment and provides equal access to the Boy Scouts and other designated youth groups. The following individual has been designated to accept allegations regarding non-discrimination policies: Superintendent of Schools, 3215 Cuming Street, Omaha, NE 68131 (531-299-9822). The following persons have been designated to handle inquiries regarding the non-discrimination policies: Director of Equity and Diversity (equityanddiversity@ops.org), 3215 Cuming St, Omaha, NE 68131 (531-299-0307).

5.6 WORKER VERIFICATION

The Contractor contracting with the District shall be required to register with and utilize an electronic verification system or program, whether the work authorization program of the Illegal Immigration Reform and Immigrant Responsibility Act of 1996, 8 U.S.C. 1324a, now known as the "E-Verify Program" or an equivalent federal program designated by the Department of Homeland Security or other federal agency authorized to verify the work eligibility status of a newly hired employee pursuant to the Immigration Reform and Control Act of 1986. The Contractor shall require all subcontractors performing work under the Contract to also register and utilize such electronic verification system. The Contractor awarded the Contract and all of such Contractor's subcontractor(s) shall use such electronic verification system to determine the work eligibility status

of each new employee physically performing any services within the State of Nebraska under the Contract. Any person whom the electronic verification system determines is ineligible or not authorized to work in the United States shall not be permitted by the Contractor or any subcontractor to perform services in Nebraska under such Contract. The Contractor shall provide such reasonable documentation as District may request from time to time during the performance of the Contract and for 5 years thereafter documenting compliance with the provisions of this Section. Failure to comply with the provisions of this Section shall constitute a default under the Contract with the District.

5.7 CIVIL RIGHTS

Contractor will comply with Title VI of the Civil Rights Act of 1964 (P.L. 88-352), as amended by the Equal Opportunity Act of 1972, all requirements imposed by or pursuant to the Regulations of the Department of Education (34 C.F.R. Part 100) issued pursuant to that title, the Pregnancy Discrimination Act of 1978, Federal Executive Order 11246, the Federal Rehabilitation Act of 1973,as amended, the Vietnam Era Veteran's Readjustment Assistance Act of 1974, Title IX of the Education amendments of 1972, the Age Act of 1972, the Americans With Disabilities Act of 1990,the Genetic Information Nondiscrimination Act of 2008, and the Nebraska Fair Employment Practice Act, Neb. Rev. Stat. §48-1122. Contractor agrees no person in the United States shall on the grounds of race, color or national origin, be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity for which OPS receives federal financial assistance from the Department; and hereby gives assurance that the Institution will immediately take any measures necessary to effectuate this Agreement. Contractor further agrees to comply with all applicable requirements of state and local laws, ordinances, and regulations regarding nondiscrimination in employment. Contractor agrees not to discriminate in its employment practices and will render services under this Agreement without regard to race, color, national origin, religion, sex (including pregnancy), marital status, sexual orientation, disability, age, genetic information, gender identity, gender expression, citizenship status, veteran status, political affiliation or economic status. Any act of discrimination committed by Contractor or failure to comply with these statutory obligations when applicable shall be a default under the Contract Documents.

5.8 SUBCONTRACTING

If Contractor intends to utilize subcontractors for the performance of any services under the Contract, OPS shall have the right to review any subcontractors that the Contractor intends to use for this Contract. Any approved subcontractor shall meet all requirements of the Contract. Subcontractors selected by the Contractor will be the direct responsibility of such Contractor and not OPS. The responsibility for coordinating and managing the activities of a subcontractor lies with the Contractor and not OPS.

5.9 TERMINATION OF CONTRACT

In the event that the Contractor executes a Contract with OPS, or is issued a Purchase Order, and fails or refuses to perform such Contract or Purchase Order according to its terms, or in the event such Contractor otherwise defaults in the performance thereof, OPS may, in addition to all other rights that it may have at law or equity, terminate such Contract or Purchase Order, and may enter into a Contract with another vendor for the same product or service. Any additional costs incurred by OPS in obtaining such Products or services from a substitute contractor, shall be paid by Contractor to OPS, in addition to any other damages that OPS may have suffered due to such default. In the event of such termination, the Contractor shall not be entitled to any further payment under the Contract. Should the cost of completing the performance of the Contract, together with such damages and expenses incurred by OPS through the default of the Contractor, at that time exceed unpaid balance of the Contract price, the Contractor shall pay the difference to OPS upon demand by OPS, and in addition may recover any other damages as OPS is entitled to recover for Contractor’s breach of Contract.

5.10 PUBLIC BENEFIT

For purposes of complying with Neb. Rev. Stat. §§ 4-108 through 4-114, if the Contractor is a sole proprietorship or a general partnership, the Contractor represents to OPS that the sole proprietor each general partner, as applicable, are citizens of the United States or that are qualified aliens under the federal Immigration and Nationality Act. Any qualified alien must provide to OPS that person's immigration status, alien number and a copy of their USCIS documentation upon request by the District.

5.11 GOVERNING LAW, JURISDICTION, AND FORUM SELECTION

The laws of the State of Nebraska shall govern the interpretation and performance of the Contractor Purchase Order between OPS and Contractor and of the Contract Documents without regard to its conflicts of laws principles. The Contractor who enters into the Contract with OPS or accept a Purchase Order from OPS shall irrevocably consent and submit to the personal jurisdiction of the state and federal courts of Nebraska. Any action brought to enforce or interpret any provision of the Contract Documents shall be brought in the state or federal courts located in Douglas County, Nebraska. The Contractor hereby acknowledges and agrees that the state and federal courts located in Douglas County, Nebraska, are proper and convenient forums in which to litigate any matter pertaining to the Bid Documents and the Contract Documents.

5.12 INDEMNITY

Contractor, on behalf of itself and its successors and assigns, hereby agrees to indemnify, defend, and hold harmless OPS and its Board members, officers, agents and employees, from any or all losses, damages, claims, liabilities, judgments, costs and expenses (including reasonable attorney's fees and expenses) arising out of or in connection with: (i) any act or omission of Contractor or Contractor's agents, contractors or employees; (ii) any default, breach, violation or non-performance of the Contract between the Contractor and OPS or (iii) any injury to persons or property or loss of life caused by Contractor or by Contractor's agents, contractors or employees, other than any such claims that are caused solely by the negligent or intentional act or omission of OPS, or its employees, agents, or contractors.

5.13 PROHIBITED ITEMS AND CONDUCT

There shall be no smoking or use of any tobacco or vaping products on/or within the property limits of OPS property. OPS strictly prohibits the illegal use of drugs, alcohol possession or consumption, and the possession of permitted and/or non-permitted firearms within the boundaries of District property. These regulations shall be enforced by the Contractor.

Portions of the Work will be performed within the OPS building or on OPS grounds while school is in session. Contractor shall take reasonable measures in conducting the Work during school hours to avoid unnecessary noise or disturbance. Offensive behavior and the use of loud, vulgar, or profane language is prohibited anywhere on OPS property and the Contractor will be required to exclude offenders from the Project site. Contractor shall take all reasonable measures necessary to avoid any unauthorized contact between employees of Contractor or any Subcontractor and any students of OPS at the Project site.

5.14 EMPLOYEE CLASSIFICATION

The Contractor agrees to abide by the provisions of Neb. Rev. Stat. 48-2901 to 48-2912, also known as the Employee Classification Act. In compliance with the Act, the Contractor shall to submit to District upon execution of the contract and upon request an affidavit attesting that (1) each individual performing services for the Contractor is properly classified under the Employee Classification Act, (2) the Contractor has completed a Federal I-9 immigration form and has such form on file for each employee performing services, (3) the Contractor has complied with Neb. Rev.

Stat. § 4-114, (4) the Contractor has no reasonable basis to believe that any individual performing services for such Contractor is an undocumented worker, and (5) as of the time of this Contract, the Contractor is not barred from contracting with the state or any political subdivision pursuant to Section 48-2912. The Contractor acknowledges that a violation of the Act is grounds for rescission of this Contract by District. The Contractor further acknowledges that providing a false affidavit under Section 48-2911 to District may subject the Contractor to the penalties of perjury and upon a second or subsequent violation the Contractor shall be barred from contracting with the state or any political subdivision for a period of three years after the date of discovery of the falsehood. The Contractor shall require any and all subcontractors who perform work pursuant to the Contract to provide a similar affidavit, which shall be made available to the District upon request.

5.15 DISTRICT FURNISHED INFORMATION

Construction Drawings of facility areas that are furnished by District are approximate and subject to on-site verification by the Contractor. Drawings are for clarification only and are not to scale.

5.16 SHOP DRAWINGS

If required by the Contract Documents, the Contractor shall furnish one (1) copy of shop drawings to the District for approval before fabrication. The District will not be responsible for or accept any equipment or material that is not constructed or manufactured in conformity with the approved shop drawings, Plans and Specifications. The District will review shop drawings as soon as reasonably practical after they are submitted.

5.17 PERFORMANCE AND PAYMENT BOND

If the amount of the Contractor's Contract exceeds $10,000, the Contractor shall furnish within ten (10) days of the award of the Contract a Contractor's Performance, Labor and Material Payment Bond for the full and faithful completion of the work required by the Contract Documents in a sum equal to the full amount of the Contract price executed by a corporate bonding company licensed to transact such business in the State of Nebraska and acceptable to the District. To be valid, the Performance, Labor and Material Bond submitted must be signed by both the Contractor and the surety on the Bond, and if signed by an attorney-in-fact for the surety, a valid power of attorney from the surety must be attached to the Bond. The expense of such bond shall be borne by the Contractor. If at any time, in the judgement of the District, a surety on such a bond becomes unable to perform its commitments under such bond, or is otherwise unacceptable to the District, the Contractor shall furnish a substitute bond, with acceptable surety, within ten (10) calendar days after receipt of written notice to do so. There shall not be a lapse in any bond furnished by Contractor. The bond must be provided on the bond form attached to these Bid Documents.

5.18 FEDERAL TAXES

Where Federal statutes exempt OPS from the payment of excise or manufacturer's taxes on materials or equipment, bidders shall exclude the amount of any Federal excise or manufacturer's taxes from its bid. Contractor shall comply with all applicable federal tax laws.

5.19 NEBRASKA STATE AND CITY SALES AND USE TAX

OPS is exempt from state and city sales and use taxes and no sales or use taxes shall be included in the bid or collected from OPS. The OPS tax-exempt number is 05-0597767. OPS will provide the Contractor with its tax-exempt form upon request. The District, a tax-exempt governmental unit, will appoint the Contractor to be its Purchasing Agent for the purpose of obtaining materials to be incorporated into the Work contemplated by these Bid Documents without the payment of sales or use taxes. Materials to be incorporated into the Project shall be purchased tax exempt from Nebraska sales and use taxes in the name of the District; and the bidder shall exclude from its bid all State of Nebraska and Local Option Sales and Use Tax for materials. The bidder shall include

State of Nebraska and Local Option Sales and Use Tax for materials which are used or consumed in performing the Work but which are not incorporated into the completed Project.

5.20 SOILS

If any soil is brought onto District property, it must be tested for environmental contaminates. Borrow soils used for the purposes other than for structural fill, such as finish grade, topsoil or surcharge, are required to be tested in the same manner for environmental contaminates. Contractor will inform District of the location of borrow soil no less than two weeks prior to its use on District property. Testing will include the collection of not less than three samples per borrow site. The District and/or their designated representative will perform soil sample collection.

Lead content of soil will be determined by analysis using either flame or furnace atomic absorption spectroscopy. Laboratories performing analysis for lead in soil will be certified by the National Lead Laboratories Accreditation Program (NLLAP) by mandatory participation in the Environmental Lead Proficiency Analytical Testing (ELPAT) program. Lead content will be reported as parts per million (ppm). Should any of the soil samples report a lead concentration greater than 200 ppm, the soil will not be allowed for use on District properties.

5.21 ASBESTOS, PCBs, OR HAZARDOUS WASTE

All known and accessible asbestos-containing material, polychlorinated biphenyls (PCBs) and hazardous waste has been or will be removed from the Project area by the District's Environmental Division. In the event Contractor encounters suspect asbestos-containing, PCB contaminated or other hazardous materials at the Project site, Contractor shall stop work immediately in the suspected contaminated area and contact the District's Environmental Division at 531-299-0180.

No asbestos containing products shall be used or installed in any District facility.

5.22 WORKER'S COMPENSATION INSURANCE

Each Contractor shall maintain at its own expense until completion of this Project and acceptance thereof by the District, Workers' Compensation Insurance coverage, covering the obligations of the Contractor in accordance with the provisions of the laws of the State of Nebraska. In case any Work is subcontracted, the Contractor shall require subcontractors similarly to provide such insurance covering the subcontractor's obligations to its employees. Each Contractor shall furnish the District with a certificate on or before the date the Agreement is signed, that such Contractor is covered by Worker's Compensation insurance for protection of their employees as required by law.

5.23 INSURANCE

The Contractor shall maintain such insurance as will protect themselves, any subcontractor, and the District, from claims arising from property damage liability, and from claims for damages because of bodily injury, including death, which may arise from and during the operations under and during the life of this Contract, whether such operations be by the Contractor or by any subcontractor or anyone directly or indirectly employed by either of them. This insurance shall be written in accordance with the limits of liability specified in the Contract Documents as outlined as follows and shall be written on an occurrence basis only. This insurance shall be written in accordance with the limits of liability specified in the following paragraphs. District shall be an additional insured on all insurance policies provided by Contractor. Contractor must at all times maintain the following insurance coverages:

Employer's Liability
$500,000 per accident
$500,000 disease, policy limit
$500,000 disease, each employee

Commercial General Liability
Bodily injury and property damage liability
$1,000,000 per occurrence
$2,000,000 general aggregate
$2,000,000 completed operations aggregate
$1,000,000 personal and advertising injury

General Liability Coverage must include the following:

(1) General Aggregate to apply on a per project basis.
(2) District shall be named as Additional Insured on a primary and non-contributory basis including completed operations.
(3) Contractor agrees to waive its rights of recovery against District. Waiver of Subrogation in favor of (District) shall be added to the policy.
(4) Contractual liability coverage shall be on a broad form basis and shall not be amended by any limiting provisions or endorsements.
(5) Products and completed operations shall be maintained for duration of work and shall be further maintained for a minimum period of two (2) years after final acceptance and payment.

Automobile liability coverage insuring both bodily injury and property damage with limits of liability per occurrence of at least $1,000,000 combined single limit. This insurance shall cover owned, non-owned and hired vehicles. Automobile liability insurance must also include insurance covering liability for transportation of asbestos containing materials.

Umbrella/Excess policy with limits of at least $2,000,000. Policy shall provide liability coverage in excess of the specified Workers Compensation/Employers Liability, Commercial General Liability and Auto Liability. Waiver of Subrogation in favor of the District shall be added to the policy. Policy limits shall apply on a per project basis.

All insurance required must be written by a company or companies licensed to transact such business either on an admitted or non-admitted basis in the State of Nebraska which are acceptable to the District. District shall be named as an additional insured on all such policies on a primary and non-contributory basis. All required policies of insurance and the certificates must provide for at least thirty (30) days written notice to District of any change in or cancellation of or termination of the coverage or coverages. All liability insurance to be furnished by Contractor shall provide "occurrence" coverage for any liability arising out of the Contract. Contractor shall maintain such liability insurance, including products and completed operations coverage, for a period of two (2) years after final acceptance of the work and shall provide District with certificates evidencing such coverage.

All projects where price quotes were solicited by bid or proposal must submit an individual insurance certificate noting all required coverages in place for that particular project prior to commencing any work on the project. Contractors or vendors who respond to small projects that are initiated by verbal request such as emergencies may submit an insurance certificate for general coverage in the amounts listed in this Section in force for a period of one-year.

5.24 BUILDERS' RISK/INSTALLATION FLOATER INSURANCE

Contractor will purchase and maintain Builder's Risk/Installation Floater Insurance equal to the amount of the Contract covering the entire Work at the Project site including all materials and equipment destined to become a part of the Work only if the Contractor is involved with construction activities related to the structural integrity of the building or any mechanical system of the building. The District and subcontractors will be an additional insured under this policy. The Contractor will be responsible for the deductible portion of any covered loss due to loss caused by

or contributed by the negligent act of the Contractor or subcontractor. This deductible shall not exceed $10,000. There will be a waiver of subrogation in favor of the District on all Builders' Risk/Installation Floater coverage. The District shall be named as an additional named insured on any Builders' Risk/ Installation Floater policy, and will be named as an additional insured and loss payee on any installation floater policy.

Minimum limits of at least:
($TBD) Jobsite
($TDB) Off-site at a Temporary Location
($TBD) In Transit
Riggers Limit: ($TBD)

Contractor agrees to waive all rights of recovery against District and its agents, officers, directors and employees for any loss insured under such policy. Contractor's insurer shall endorse the policy to waive subrogation against the District and its agents, officers, directors and employees.

5.25 RIGGERS COVERAGE (if applicable)

If the Contractor will be using a crane or other equipment to rig or lift equipment or materials as part of this Project, the Contractor will maintain Riggers Coverage equal to the most expensive item rigged and lifted as part of the installation.

5.26 PAYMENT

Applications for payment may be submitted up to twice monthly. All such applications must be approved by the District's Board of Education at a regular meeting, usually held the first and third Monday of the month. Contractor should allow at least fourteen (14) business days prior to a Board meeting when submitting payment applications. Contractor shall submit applications for progress payments via email to the Project Manager (PM) and the Schoolhouse Planning Accounts Payable inbox at (planning.ap@ops.org). Invoices must be approved and processed 10 workdays prior to the next Board date where approval is requested for payment. Payments are generally issued the Tuesday following the Board meetings on the first and third Mondays of a month, except in those instances when the normal twice-monthly Monday Board of Education meeting is delayed, due to a holiday or other extenuating circumstance.

Such application for payment shall be accompanied by such other documents as are required by the Contract Documents or that may be reasonably required by the District. Such application for payment shall be reasonably detailed and shall include the value of any Work performed and materials incorporated into the Work, based on the Contractor's approved schedule of values, less any applicable retainage and less the aggregate of all previous payments. Retainage in the amount of 10% of the amount of each application for payment shall be retained from each payment until the work is 50% completed at which time retainage shall be reduced to 5% of each subsequent application for payment. District may reinstate 10% retainage at any time as permitted by law. Based on the PM's observations and an evaluation of the Contractor's applications for payment as submitted to the PM, the PM will determine the amounts owing to the Contractor and will forward the Contractor's Certificates for Payment to District for review and action in such amounts and with such recommendations as PM deems appropriate. Final approval of any application for payment shall be made by the District. At Substantial Completion of the Work, retainage will be paid to Contractor, less 125% of the amount estimated by District to complete any incomplete Work and the amount of unsettled claims against Contractor. Final payment of all remaining unpaid amounts will be paid as provided in Section 5.27 (Final Payment and Project Closeout) hereof.

The Contractor shall maintain books, records, and documents in accordance with generally accepted accounting principles and procedures and which sufficiently and properly document and calculate all charges billed to OPS for a period of at least four (4) years following the date of final payment or completion of any required audit, whichever is later. Records to be maintained include

both financial records and service records. The Contractor shall permit the Auditor of the OPS Board of Education or any authorized representative of OPS, and where Federal funds are involved, the Comptroller General of the United States, or any other authorized representative of Federal or State government, to access and examine, audit, excerpt and transcribe any directly pertinent books, documents, papers, electronically or optically stored and created records or other records of the Contractor relating to orders, invoices, or payments or any other documentation or materials pertaining to the Contract, wherever such records may be located during normal business hours. The Contractor shall not impose a charge for audit or examination of the Contractor's books and records. If an audit discloses incorrect billings or improprieties, OPS reserves the right to charge the Contractor for the cost of the audit and appropriate reimbursement. Evidence of criminal conduct will be turned over to the proper authorities.

5.27 FINAL PAYMENT AND PROJECT CLOSEOUT

Final payment shall not become due until the Contractor has provided the following documents to the District:

5.27.1 A satisfactorily completed punch list of deficiencies required to satisfy warranty requirements or been judged incomplete by District personnel.

5.27.2 A complete unconditional waiver and release of all lien and bond claims and rights arising out of this Contract, including Contractor and all subcontractors and all principal material suppliers or receipts showing payment in full in lieu thereof.

5.27.3 An affidavit of Contractor stating that the releases of liens payment receipts provided to the District by Contractor for labor and/or material supplied to the Project include all subcontractors and principal suppliers.

5.27.4 Contractor may, if any subcontractor refuses to furnish a lien waiver, furnish a bond satisfactory to the District, to protect District from against any bond claims or liens from such subcontractor.

5.27.5 Original Consent of Surety to Final Payment.

5.27.6 Material Safety Data Sheets (MSDS) for all materials used in the completion of work.

5.27.7 Original Contractor's one (1) year Labor & Workmanship Warranty.

5.27.8 Original Manufacturer's Material & Equipment Warranty with Contractor's assignment to the District.

If any lien remains unsatisfied after all payments are made, the Contractor shall refund to the District all monies the latter may be compelled to pay in discharging such a lien, including all costs, interest and reasonable attorney's fee.

5.28 COMPLIANCE WITH LAW

The Contractor, in performance of the Work called for in the Contract Documents, will comply with all applicable governmental laws, ordinances, regulations, and codes. Contractor shall have the necessary rights, licenses and approvals required to provide the specified Products and services.

The laws of the State of Nebraska shall govern the interpretation and performance of the Contract between OPS and Contractor and of the Contract Documents without regard to its conflicts of laws principles. The Contractor who enters into the Contract with the District shall irrevocably consent and submit to the personal jurisdiction of the state and federal courts of Nebraska. Any action

brought to enforce or interpret any provision of the Contract Documents shall be brought in the state or federal courts located in Douglas County, Nebraska. The Contractor hereby acknowledges and agrees that the state and federal courts located in Douglas County, Nebraska, are proper and convenient forums in which to litigate any matter pertaining to the Bid Documents or the Contract.

5.29 DEFECTIVE WORK AND WARRANTIES

The District, or its designated representative, prior to final completion and acceptance of the Work, shall have the right to reject any work, materials, or equipment that are defective, which Contractor shall promptly correct. For a period of one (1) year from the date of Substantial Completion of the Contractor's work, the Contractor will, upon demand by the District, promptly make all repairs and replacements to the work at Contractor's cost due to any defects in the equipment, material or workmanship furnished and performed under the Contract Documents. This warranty is in addition to all other warranties provided in the Plans and Specifications. In addition to the Labor and Material Warranty, all manufacturers' warranties provided by the equipment or material manufacturers must be assigned to the District.

5.30 PERMITS

The successful Contractor shall be responsible for securing the necessary permits required to perform the work. Fees are not assessed against the District for permits issued by the Permits and Inspections Division, City of Omaha; however, fees for electrical work are assessed by the State of Nebraska and shall be paid by Contractor.

5.31 THE DISTRICT'S RIGHT TO DO WORK

If the Contractor should neglect to prosecute the work properly or fail to perform any provision of this Contract, the District, after seven (7) calendar days' written notice to the Contractor may, without prejudice to any other remedy it may have, make good such deficiencies and may deduct the cost thereof from the payment then or thereafter due the Contractor.

5.32 PERFORMANCE OF WORK AND LIQUIDATED DAMAGES

It is hereby understood and mutually agreed, by and between the Contractor and the District, that the date of beginning, rate of progress, and the time for completion of the work to be done hereunder are ESSENTIAL CONDITIONS of this Contract; and it is further mutually understood and agreed that the work embraced in this Contract shall be commenced on a date to be specified in the Specifications.

The Contractor agrees that the Project shall be prosecuted regularly, diligently and uninterruptedly at such rate of progress as will ensure full completion thereof within the time specified. It is expressly understood and agreed by and between the Contractor and the District, that the time for the completion of the Project described herein is a reasonable time for the completion of the same, taking into consideration the average climatic range and usual industrial prevailing in this locality.

IF THE CONTRACTOR SHALL NEGLECT, FAIL OR REFUSE TO COMPLETE THE PROJECT WITHIN THE TIME SPECIFIED IN THE CONTRACT DOCUMENTS, then the Contractor does hereby agree, as a part consideration for the awarding of this Contract, to pay to the District the amount specified in the Contract, not as a penalty, but as liquidated damages for such breach of Contract as hereinafter set forth, for each and every calendar day that the Contractor shall be in default after the time stipulated in the Contract for Substantial Completion of the Work.

The liquidated damages amount is fixed and agreed upon by and between the Contractor and the District because of the impracticability and difficulty of fixing and ascertaining the actual damages the District would in such event sustain, and said amount is agreed to be the amount of damages which the District would sustain and said amounts shall be retained from time to time by the District

from current periodical estimates. It is further agreed that time is of the essence of each and every portion of this Contract and of the Plans and Specifications wherein a definite and certain length of time is fixed for the performance of any act whatsoever and where under the Contract an additional time is allowed for the completion of any Work, the new time limit fixed by such extension shall be of the essence of this Contract.

Contractor shall not be charged with liquidated damages for those days of delay that are solely due to the occurrence of any of the following that actually delay the performance of the Work:

(1) any material shortage caused by preference, priority or allocation order duly issued by the Government, or

(2) any unforeseeable causes beyond the control and without the fault or negligence of the Contractor, including, but not restricted to, acts of God, or of the public enemy, fires, floods, epidemics, quarantine, restrictions, strikes which preclude the Contractor from working on the site or from obtaining materials necessary to the progress of the work and material shortages due to freight or trade embargoes.

Provided that each case, the Contractor must, within seven (7) calendar days from the beginning of such delay from such cause, request an extension of time by change order, which must be approved by the District. The liquidated damages provision regarding delays does not in any way impact the District's right to recover its actual damages for defective performance of the contracted-for scope of Work.

5.33 DISTRICT'S RIGHT TO TERMINATE CONTRACT

The Contractor shall be in default and the Contract with Contractor may be terminated by the District should any one or more of the following conditions occur:

5.33.1 The Contractor should be adjudged as bankrupt.

5.33.2 The Contractor makes a general assignment for the benefit of creditors.

5.33.3 A receiver is appointed to take over the Contractor's affairs.

5.33.4 The Contractor fails to prosecute the Work with due diligence and carry the Work forward in accordance with the Project schedule and time limits set forth in the Contract.

5.33.5 The Contractor fails to promptly pay any subcontractor or suppliers without justification.

5.33.6 The Contractor fails to perform one or more of the provisions of the Contract.

In such cases, the District may serve written notice on the Contractor and the Surety on Contractor's performance bond stating its intention to exercise one or more of the remedies set forth in Section 5.36 and the grounds upon which the District bases its right to exercise such remedy.

5.34 DISTRICT REMEDIES FOR DEFAULT

In the event the District serves written notice referred to in Section 5.33 on Contractor, District may, without prejudice to any other right or remedy, exercise one or more of the following remedies at once.

5.34.1 The District may terminate the employment of the Contractor, effective immediately. Should the Contractor's Surety fail to commerce completion of the Contract within the ten (10) calendar days after notice of termination, the District may:

5.34.1.1 Take over the work, taking possession of and use all materials, tools, equipment and appliances on the premises, and

5.34.1.2 prosecute the work to completion by such means as it shall deem best.

In the event of such termination of employment, the Contractor shall not be entitled to any further payment under the Contract until the work is completed and accepted. If the unpaid balance of the Contract price, including compensation for any damages or expenses incurred by the District through the default of the Contractor at that time, exceeds the cost of completing the work, then such excess shall be paid to the Contractor upon completion and acceptance by District and satisfaction of any claims of District against Contractor. Should such damages or expenses incurred by the District through the default of the Contractor at that time exceed unpaid balances of the Contract price, the Contractor and his Surety shall pay the difference to the District.

5.34.2 The District may take control of the work and either:

5.34.2.1 Correct the deficiencies of the Contractor itself, or

5.34.2.2 Direct the activities of the Contractor and in doing so, employing such additional help as the District deems advisable.

In such event, the District shall be entitled to collect the cost thereof from the Contractor and its Surety, or deduct from any payment then or thereafter due the Contractor the cost incurred by the District to have such deficiencies corrected or expenses incurred through the default of the Contractor.

5.34.3 The District may require the Surety on the Contractor's bond to take control of the Work at once and see to it that all the deficiencies of the Contractor are corrected, with due diligence. As between the District and Contractor, the cost of correcting such deficiencies shall all be borne by the Surety.

5.34.4 If the Surety takes over the Project, either upon termination of employment of the Contractor or upon instructions from the District to do so, the provisions of the Contract Documents shall govern in respect to Work done by the Surety, the Surety being substituted for the Contractor as to such provisions including provisions as to payment for the Work and the provisions as to the right of the District to do the Work itself, or take control of the Work.

5.35 TERMINATION FOR CONVENIENCE

At any time during the term of the Contract, the District may terminate the Contract for its convenience and without cause by written notice to Contractor given at any time during the term if the Contract, which notice shall specify the effective date of termination. In the event that the District elects to terminate this Contract without cause, the District will remain obligated to take possession of and pay the Contract price for all Work that has been completed and accepted by the District at the time the notice of such termination is given. The parties shall be released of further obligation under the Contract except for those obligations that are to survive termination and the obligations of the parties.

5.36 GOVERNING LAW, JURISDICTION, AND FORUM SELECTION

The laws of the State of Nebraska shall govern the interpretation and performance of the Contract or Purchase Order between OPS and Contractor and of the Contract Documents without regard to

its conflicts of laws principles. The Contractor who enters into the Contract with OPS or accept a Purchase Order from OPS shall irrevocably consent and submit to the personal jurisdiction of the state and federal courts of Nebraska. Any action brought to enforce or interpret any provision of the Contract Documents shall be brought in the state or federal courts located in Douglas County, Nebraska. The Contractor hereby acknowledges and agrees that the state and federal courts located in Douglas County, Nebraska, are proper and convenient forums in which to litigate any matter pertaining to the Bid Documents and the Contract Documents.

5.37 ASSIGNMENT

Contractor awarded the Contract or issued the purchase order shall not assign the same in whole or in part to any other person or entity without the prior written consent of OPS, which shall not be unreasonably withheld. No interest of Contractor in the Contract shall be transferred by operation of law.

5.38 PUBLIC RECORDS

As a Nebraska political subdivision, OPS is subject to the requirements of the Nebraska public records laws (Neb. Rev. Stat. §§ 84-712 to 84-712.09), which allows members of the public to have access to any information or records, regardless of physical form, of or belonging to a Nebraska political subdivision, such as OPS. As defined by Nebraska law, examples of public records subject to disclosure during a bid procedure will include the Bid Documents, a bidder's bid and any other document submitted by a bidder to OPS, bidder questions and OPS responses, any contract between OPS and the successful bidder, any purchase order issued to the successful bidder by OPS, or any other public record in the possession of OPS regarding this bidding and contracting process, whether created before or after the Bid Documents were issued by OPS and whether created by OPS, the bidders or any other third party. These public records will be open to public inspection and copying unless exempted from disclosure in accordance with the OPS's interpretation and application of applicable law. Documents exempt from disclosure under the Nebraska public records laws are enumerated at Neb. Rev. Stat. §712.05. It shall be the sole responsibility of a bidder (a) to notify OPS, as soon as possible, of any requested redactions to any such information or records provided by the bidder to OPS that may otherwise be required to be open to public inspection and copying and (b) to indicate the legal basis for such requested redactions. In addition, bidder agrees to defend OPS in any legal challenge to such requested redactions at the bidder's own expense. The failure of a bidder to request redactions to any information or records released by OPS shall constitute a complete waiver of any and all claims for damages caused by any such release. Any attempt by a bidder to request a redaction or otherwise claim confidentiality as to any public record in the possession of OPS will be ineffective and not, by itself, binding upon OPS unless OPS has independently determined that the bidder's request that a document, or portion thereof, is entitled to be withheld from public inspection and copying or if OPS is ordered by a court of appropriate jurisdiction to allow public inspection and copying of the document.

BID FORM
BID NO.: 25-017

OPS Blackburn VAVs & HVAC Control Replacement Project

Proposal of _____, a [ ] corporation organized and existing under the laws of the State of _____; a [ ] limited liability company organized and existing under the laws of the State of _____; a [ ] partnership, organized and existing under the laws of the State of _____; or an [ ] individual (check the appropriate box).

TO: Omaha Public Schools
Purchasing Division
3215 Cuming St.
Omaha, NE 68131

The undersigned, having familiarized themselves with the work at the place where the Work is to be done and with the Plans and Specifications and other Contract Documents hereby proposes and agrees to perform everything required to be performed, and to provide and furnish all labor, materials, tools, expendable equipment and all utility and transportation services necessary to perform and complete in a workmanlike manner all of the Work required by the specifications for OPS Blackburn VAVs & HVAC Control Replacement Project, all in strict accordance with the Plans, Specifications and other Contract Documents as prepared by the Douglas County School District 0001 ("District") for the consideration hereinafter set forth.

In submitting this bid the Bidder certifies to the District that the bidder is complying with, and will continue to comply with, all applicable Fair Labor Standards set forth in Chapter 73 of the Nebraska Revised Statutes.

The undersigned agrees that this bid cannot be withdrawn and can be accepted by the District for a period of ninety (90) days subsequent to the opening of bids without the consent of the Board of Education. The undersigned further acknowledges that the District reserves the right to accept or reject any or all bids and any part thereof and to waive any and all technicalities and irregularities.

The undersigned proposes to furnish all labor and materials (required to be furnished by the Contractor) and complete all Work as required by the Contract Documents for this Project for the following amount.

LUMP SUM BID

OPS Blackburn VAVs & HVAC Control Replacement Project -- Lump Sum Base Bid:

_____Dollars ($_____)
(amount in words) (amount in numerals)

In the event of a discrepancy between the amount shown in figures and the amount shown in writing on the previous pages, the written amount shall take precedence and will be used.

DISCOVERY ALLOWANCE:
Contractor to confirm that the **required $20,000 discovery allowance** is included in the bid. The discovery allowance is to be used at the owner's directive. Proposed change costs shall be submitted for review before approval. Any remaining unused funds shall be credited to the owner on the final pay app. The allowance shall be tracked on all pay apps and include any deductions and remaining balance. Write out the amount included in the base bid.

_____Dollars ($_____)
(amount in words) (amount in numerals)

UNIT PRICES

Control valve replacement - replace existing control valve with new modulating control valve and actuator with associated wiring and programing.

1/2 INCH

Manufacturer	Model No.	Unit Price	Est. Quantity	Extended Price
			10	

3/4 INCH

Manufacturer	Model No.	Unit Price	Est. Quantity	Extended Price
			30	

1 INCH

Manufacturer	Model No.	Unit Price	Est. Quantity	Extended Price
			30	

1-1/2 INCH

Manufacturer	Model No.	Unit Price	Est. Quantity	Extended Price
			30	

2 INCH

Manufacturer	Model No.	Unit Price	Est. Quantity	Extended Price
			10	

3 INCH

Manufacturer	Model No.	Unit Price	Est. Quantity	Extended Price
			10	

Control damper actuator replacement – replace existing damper control actuator with new modulating control actuator with associated wiring and programing.

Manufacturer	Model No.	Unit Price	Est. Quantity	Extended Price
			50	

Duct temperature sensor – install new duct temperature sensor with associated wiring and programing.

Manufacturer	Model No.	Unit Price	Est. Quantity	Extended Price
			15	

Water temperature sensor – install new water temperature sensor with thermal well with associated wiring and programing.

Manufacturer	Model No.	Unit Price	Est. Quantity	Extended Price
			15	

(Initial: _____)
(Date: _____)

Attachments:
1. Bid Bond
2. Safety Data Sheets
3. Warranty Information

SIGNATURE PAGE
BID NO.: 25-017

The undersigned certifies that the information in the foregoing bid is submitted in accordance with the requirements of the Bid Documents and is true and correct to the best of the undersigned's knowledge and belief. The undersigned further represents to the District that the undersigned is duly authorized to sign this Signature Page on behalf of the referenced company.

COMPANY NAME: _____

ADDRESS: _____

CITY/STATE/ZIP: _____

EMAIL ADDRESS: _____

PHONE: _____ FAX #: _____

SIGNATURE: _____
Bids must be signed to be valid.

PRINTED NAME: _____

TITLE: _____

DATE: _____

Acknowledge Receipt of Bid Addendum:

Addenda No. _____ Dated: _____
Addenda No. _____ Dated: _____

Addenda No. _____ Dated: _____

PERFORMANCE, LABOR AND MATERIALS BOND

KNOW ALL MEN BY THESE PRESENTS That we _____as principal and _____ as Surety are held and firmly bound to the Board of Education of the Douglas County School District 0001, a political subdivision of the State of Nebraska, in the penal sum of $ _____ to be paid to said Board of Education of the Douglas County School District 0001 for which payment to be well and truly made, we bind ourselves and each of us, our and each of our heirs, executors, administrators, successors and assigns, jointly and severally firmly by these presents.

Dated this_____day _____A.D., 20_____.

The condition of this obligation is that:

Whereas, by even date herewith the said principal has entered into a contract with the said Board of Education of the Douglas County School District 0001 to perform the labor and furnish the material for_____ _____a copy of which said contract is attached hereto and made a part hereof.

NOW THEREFORE, the conditions of this obligation are such that if the said principal shall duly perform and observe all the stipulations and agreements in said contract on his part to be performed and observed, then and in that event this obligation shall be void and of no effect, but otherwise shall be and remain in full force and effect. It is expressly agreed that any alterations which may be made therein by agreement between the said principal and the said Board of Education of the Douglas County School District 0001, in the terms of said contract, or the nature of the work to be done there under, or the giving of any extensions of time for performing the said contract, or of any of the stipulations therein contained, and on the part of said principal to be performed, or any other forbearance shall not in any way release the said Surety from this liability under the above written bond. It is further expressly agreed and understood that this Bond shall stand as Surety for the payment of all laborers and mechanics for labor that shall be performed and for the payment for material and equipment rental which is actually used or rented in performing said contract.

IN TESTIMONY WHEREOF, the said parties hereto have hereunto set their hands this _____day of _____ _____, 20____and said Surety has caused these presents to be sealed with its corporate seal and duly attested by the signature of its attorney in fact, and their authority is attached hereto and made a part hereof.

_____ _____

_____ _____

(Principal) (Surety)

In the presence of _____

EXHIBIT A

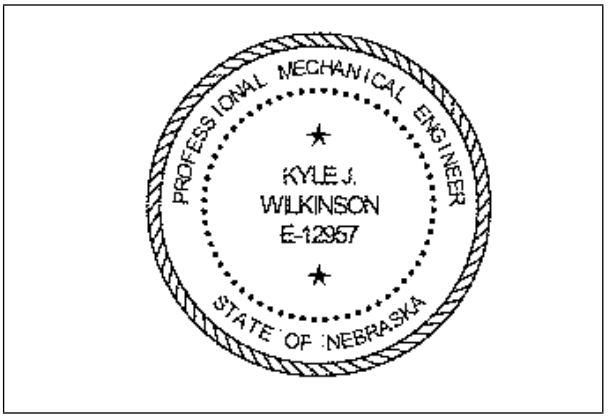
[PROJECT SPECIFICATIONS]

EXHIBIT B

[PROJECT DRAWINGS]

SECTION 00 01 05

CERTIFICATIONS PAGE



I hereby certify that the portion of this technical submission described below was prepared by me or under my direct supervision and responsible charge. I am a duly registered engineer under the laws of the State of Nebraska and will be the Coordinating Professional on this project.

Kyle J Wilkinson E-12957

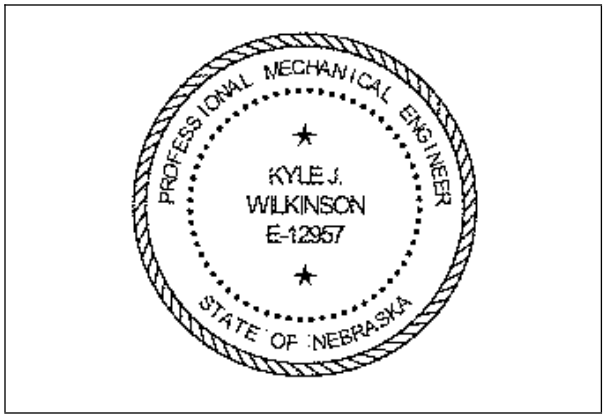
Name (Printed) Registration Number

Signature

Drawings covered by this Seal:
T0.0, M series,

Sections covered by this Seal:
Divisions 00, 01, 23

Date Issued: 05/20/2025



I hereby certify that the portion of this technical submission described below was prepared by me or under my direct supervision and responsible charge. I am a duly registered engineer under the laws of the State of Nebraska.

Kyle J Wilkinson E-12957

Name (Printed) Registration Number

Signature

Drawings covered by this Seal:
T0.0, M series

Sections covered by this Seal:
Divisions 00, 01, 23

Date Issued: 05/20/2025

END OF SECTION 00 01 05

SECTION 00 01 10

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END OF SECTION 0 01 10

SECTION 00 01 15

LIST OF DRAWING SHEETS

PART 1 - GENERAL

1.01 LIST OF DRAWINGS

GENERAL

T0.0 Cover Sheet

MECHANICAL

M0.0 Mechanical Notes, Symbols and Abbreviations
MD1.1- First Floor Mechanical Demo Plan – Area A
MD1.2- First Floor Mechanical Demo Plan – Area B
MD1.3- First Floor Mechanical Demo Plan – Area C
MD2.1- First Floor Mechanical Demo Plan – Area D
MD2.2- First Floor Mechanical Demo Plan – Area E
M1.1- First Floor Mechanical Plan – Area A
M1.2- First Floor Mechanical Plan – Area B
M1.3- First Floor Mechanical Plan – Area C
M2.1- Second Floor Mechanical Plan – Area D
M2.2- Second Floor Mechanical Plan – Area E

MD 3.1- Mechanical Details and Schedules

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 00 01 15

SECTION 01 31 00

PROJECT MANAGEMENT AND COORDINATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section includes administrative provisions for coordinating construction operations on Project including, but not limited to, the following:

1. General coordination procedures.
2. Coordination drawings.
3. RFIs.
4. Digital project management procedures.
5. Project meetings.

1.03 DEFINITIONS

A. BIM: Building Information Modeling.

B. RFI: Request for Information. Request from Owner, Architect / engineer, or Contractor seeking information required by or clarifications of the Contract Documents.

1.04 INFORMATIONAL SUBMITTALS

A. Subcontract List: Prepare a written summary identifying individuals or firms proposed for each portion of the Work, including those who are to furnish products or equipment fabricated to a special design. Include the following information in tabular form:

1. Name, address, telephone number, and email address of entity performing subcontract or supplying products.
2. Number and title of related Specification Section(s) covered by subcontract.
3. Drawing number and detail references, as appropriate, covered by subcontract.

1.05 **GENERAL COORDINATION PROCEDURES**

A. Coordination: Coordinate construction operations included in different Sections of the Specifications to ensure efficient and orderly installation of each part of the Work. Coordinate construction operations included in different Sections that depend on each other for proper installation, connection, and operation.

1. Schedule construction operations in sequence required to obtain the best results where installation of one part of the Work depends on installation of other components, before or after its own installation.
2. Coordinate installation of different components to ensure maximum performance and accessibility for required maintenance, service, and repair.
3. Make adequate provisions to accommodate items scheduled for later installation.

B. Administrative Procedures: Coordinate scheduling and timing of required administrative procedures with other construction activities and scheduled activities of other contractors to avoid conflicts and to ensure orderly progress of the Work. Such administrative activities include, but are not limited to, the following:

1. Preparation of Contractor's construction schedule.
2. Preparation of the schedule of values.
3. Installation and removal of temporary facilities and controls.
4. Delivery and processing of submittals.
5. Progress meetings.
6. Preinstallation conferences.
7. Project closeout activities.
8. Startup and adjustment of systems.

1.06 REQUEST FOR INFORMATION (RFI)

A. General: Immediately on discovery of the need for additional information, clarification, or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI in the form specified.

1. Architect / engineer will return without response those RFIs submitted to Architect / engineer by other entities controlled by Contractor.
2. Coordinate and submit RFIs in a prompt manner so as to avoid delays in Contractor's work or work of subcontractors.

B. Content of the RFI: Include a detailed, legible description of item needing information or interpretation and the following:

1. Project name.
2. Project number.
3. Date.
4. Name of Contractor.
5. Name of Architect / engineer
6. RFI number, numbered sequentially.
7. RFI subject.
8. Specification Section number and title and related paragraphs, as appropriate.
9. Drawing number and detail references, as appropriate.
10. Field dimensions and conditions, as appropriate.
11. Contractor's suggested resolution. If Contractor's suggested resolution impacts the Contract Time or the Contract Sum, Contractor shall state impact in the RFI.
12. Contractor's signature.
13. Attachments: Include sketches, descriptions, measurements, photos, Product Data, Shop Drawings, coordination drawings, and other information necessary to fully describe items needing interpretation.

C. RFI Forms: AIA standard Document or approved Contractors standard document

D. Architect / engineer's Action: Architect / engineer will review each RFI, determine action required, and respond. Allow 7 working days for Architect / engineer's response for each RFI. RFIs received by Architect / engineer after 1:00 p.m. will be considered as received the following working day.

1. The following Contractor-generated RFIs will be returned without action:

a. Requests for approval of submittals.

b. Requests for approval of substitutions.
c. Requests for approval of Contractor's means and methods.
d. Requests for coordination information already indicated in the Contract Documents.
e. Requests for adjustments in the Contract Time or the Contract Sum.
f. Requests for interpretation of Architect / engineer's actions on submittals.
g. Incomplete RFIs or inaccurately prepared RFIs.

2. Architect / engineer's action may include a request for additional information, in which case Architect / engineer's time for response will date from time of receipt by Architect / engineer of additional information.
3. Architect / engineer's action on RFIs that may result in a change to the Contract Time or the Contract Sum may be eligible for Contractor to submit Change Proposal according to Section 012600 "Contract Modification Procedures."

a. If Contractor believes the RFI response warrants change in the Contract Time or the Contract Sum, notify Architect / engineer in writing within 10 days of receipt of the RFI response.

E. RFI Log: Prepare, maintain, and submit a tabular log of RFIs organized by the RFI number.

F. On receipt of Architect / engineer's action, update the RFI log and immediately distribute the RFI response to affected parties. Review response and notify Architect / engineer within 7 days if Contractor disagrees with response.

1.07 DIGITAL PROJECT MANAGEMENT PROCEDURES

A. Architect / engineer's Data Files Not Available: Architect / engineer will not provide Architect / engineer's BIM model or CAD drawing digital data files for Contractor's use during construction.

B. Use of Architect / engineer's Digital Data Files: Digital data files of Architect / engineer's BIM model or CAD drawings may be requested of the Architect / engineer for Contractor's use during construction.

1. Contractor must fill out the architect / engineer’s waiver form and pay the applicable fee.

C. PDF Document Preparation: Where PDFs are required to be submitted to Architect / engineer, prepare as follows:

1. Assemble complete submittal package into a single indexed file incorporating submittal requirements of a single Specification Section and transmittal form with links enabling navigation to each item.
2. Name file with submittal number or other unique identifier, including revision identifier.
3. Certifications: Where digitally submitted certificates and certifications are required, provide a digital signature with digital certificate on where indicated.

1.08 PROJECT MEETINGS

A. General: Schedule and conduct meetings and conferences at Project site unless otherwise indicated.

B. Preconstruction Conference: Architect / engineer will schedule and conduct a preconstruction conference before starting construction, at a time convenient to Owner and Architect / engineer.

1. Attendees: Authorized representatives of Owner, architect / engineer, and their consultants; Contractor and its superintendent; major subcontractors; suppliers; and other concerned parties shall attend the conference. Participants at the conference shall be familiar with Project and authorized to conclude matters relating to the Work.
2. Agenda: Discuss items of significance that could affect progress, including the following:

    a. Responsibilities and personnel assignments.
    b. Tentative construction schedule.
    c. Phasing.
    d. Critical work sequencing and long lead items.
    e. Designation of key personnel and their duties.
    f. Lines of communications.
    g. Use of web-based Project software.
    h. Procedures for processing field decisions and Change Orders.
    i. Procedures for RFIs.
    j. Procedures for testing and inspecting.
    k. Procedures for processing Applications for Payment.
    l. Distribution of the Contract Documents.
    m. Submittal procedures.
    n. Sustainable design requirements.
    o. Preparation of Record Documents.
    p. Use of the premises
    q. Work restrictions.
    r. Working hours.
    s. Owner's occupancy requirements.
    t. Responsibility for temporary facilities and controls.
    u. Procedures for moisture and mold control.
    v. Procedures for disruptions and shutdowns.
    w. Construction waste management and recycling.
    x. Parking availability.
    y. Office, work, and storage areas.
    z. Equipment deliveries and priorities.
    aa. First aid.
    bb. Security.
    cc. Progress cleaning.

3. Minutes: Entity responsible for conducting meeting will record and distribute meeting minutes.

C. Progress Meetings: Conduct progress meetings at regular (minimum monthly) intervals or as required and decided by owner.

1. Coordinate dates of meetings with preparation of payment requests.
2. Attendees: In addition to representatives of Owner, and Architect / engineer, each contractor, subcontractor, supplier, and other entity concerned with current progress or involved in planning, coordination, or performance of future activities shall be represented at these meetings. All participants at the meeting shall be familiar with Project and authorized to conclude matters relating to the Work.

3. Agenda: Review and correct or approve minutes of previous progress meeting. Review other items of significance that could affect progress. Include topics for discussion as appropriate to status of Project.

    a. Contractor's Construction Schedule: Review progress since the last meeting. Determine whether each activity is on time, ahead of schedule, or behind schedule, in relation to Contractor's construction schedule. Determine how construction behind schedule will be expedited; secure commitments from parties involved to do so. Discuss whether schedule revisions are required to ensure that current and subsequent activities will be completed within the Contract Time.

        1) Review schedule for next period.

    b. Review present and future needs of each entity present, including the following:

        1) Interface requirements.
        2) Sequence of operations.
        3) Resolution of BIM component conflicts.
        4) Status of submittals.
        5) Status of sustainable design documentation.
        6) Deliveries.
        7) Off-site fabrication.
        8) Access.
        9) Site use.
        10) Temporary facilities and controls.
        11) Progress cleaning.
        12) Quality and work standards.
        13) Status of correction of deficient items.
        14) Field observations.
        15) Status of RFIs.
        16) Status of Proposal Requests.
        17) Pending changes.
        18) Status of Change Orders.
        19) Pending claims and disputes.
        20) Documentation of information for payment requests.

4. Minutes: Entity responsible for conducting the meeting will record and distribute the meeting minutes to each party present and to parties requiring information.

    a. Schedule Updating: Revise Contractor's construction schedule after each progress meeting where revisions to the schedule have been made or recognized. Issue revised schedule concurrently with the report of each meeting.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 01 31 00

SECTION 01 33 00

SUBMITTAL PROCEDURES

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes requirements for the submittal schedule and administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals.

B. Contractor will provide and set up an electronic submittal sharing web based program. The site will be initially set up by the contractor. All submittals, RFIs, etc. will be transmitted and approved through this site. All references to submittals below will be through the web program, no paper copies are required unless otherwise specified.

1.02 DEFINITIONS

A. Action Submittals: Written and graphic information and physical samples that require Architect's responsive action.

B. Informational Submittals: Written and graphic information and physical samples that do not require Architect's responsive action. Submittals may be rejected for not complying with requirements.

1.03 ACTION SUBMITTALS

A. Submittal Schedule: Submit a schedule of submittals, arranged in chronological order by dates required by construction schedule. Include time required for review, ordering, manufacturing, fabrication, and delivery when establishing dates. Include additional time required for making corrections or modifications to submittals noted by the Architect and additional time for handling and reviewing submittals required by those corrections.

1.04 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Architect's Digital Data Files: Electronic copies of CAD Drawings of the Contract Drawings will not be provided by Architect for Contractor's use in preparing submittals.

1. Architect will furnish Contractor one set of digital data drawing files of the Contract Drawings for use in preparing Shop Drawings.

a. Architect makes no representations as to the accuracy or completeness of digital data drawing files as they relate to the Contract Drawings.
b. Contractor shall execute a data licensing agreement in a form acceptable to the Owner and Architect.

B. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.

1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
2. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.

a. Architect reserves the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

C. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.

1. Initial Review: Allow 15 days for initial review of each submittal. Allow additional time if coordination with subsequent submittals is required. Architect will advise Contractor when a submittal being processed must be delayed for coordination.
2. Intermediate Review: If intermediate submittal is necessary, process it in same manner as initial submittal.
3. Resubmittal Review: Allow 15 days for review of each resubmittal.

D. Identification and Information: Place a permanent label or title block on each paper copy submittal item for identification.

1. Indicate name of firm or entity that prepared each submittal on label or title block.
2. Provide a space approximately 6 by 8 inches on label or beside title block to record Contractor's review and approval markings and action taken by Architect.
3. Include the following information for processing and recording action taken:

a. Project name.
b. Date.
c. Name of Architect.
d. Name of Construction Manager.
e. Name of Contractor.
f. Name of subcontractor.
g. Name of supplier.
h. Name of manufacturer.
i. Submittal number or other unique identifier, including revision identifier.

1) Submittal number shall use Specification Section number followed by a decimal point and then a sequential number (e.g., 061000.01). Resubmittals shall include an alphabetic suffix after another decimal point (e.g., 061000.01.A).

j. Number and title of appropriate Specification Section.
k. Drawing number and detail references, as appropriate.
l. Location(s) where product is to be installed, as appropriate.
m. Other necessary identification.

E. Identification and Information: Identify and incorporate information in each electronic submittal file as follows:

1. Assemble complete submittal package into a single indexed file with links enabling navigation to each item.
2. Name file with submittal number or other unique identifier, including revision identifier.

a. File name shall use project identifier and Specification Section number followed by a decimal point and then a sequential number (e.g., LNHS-061000.01). Resubmittals shall include an alphabetic suffix after another decimal point (e.g., LNHS-061000.01.A).

3. Provide means for insertion to permanently record Contractor's review and approval markings and action taken by Architect.
4. Include the following information on an inserted cover sheet:

    a. Project name.
    b. Date.
    c. Name and address of Architect.
    d. Name of Construction Manager.
    e. Name of Contractor.
    f. Name of firm or entity that prepared submittal.
    g. Name of subcontractor.
    h. Name of supplier.
    i. Name of manufacturer.
    j. Number and title of appropriate Specification Section.
    k. Drawing number and detail references, as appropriate.
    l. Location(s) where product is to be installed, as appropriate.
    m. Related physical samples submitted directly.
    n. Other necessary identification.

F. Options: Identify options requiring selection by the Architect.

G. Deviations: Identify deviations from the Contract Documents on submittals.

H. Additional Paper Copies: Unless additional copies are required for final submittal, and unless Architect observes noncompliance with provisions in the Contract Documents, initial submittal may serve as final submittal.

1. Submit one copy of submittal to concurrent reviewer in addition to specified number of copies to Architect.

I. Transmittal: Assemble each submittal individually and appropriately for transmittal and handling. Transmit each submittal using a transmittal form. Architect will discard submittals received from sources other than Contractor.

1. Transmittal Form: Use AIA Document G810.
2. On an attached separate sheet, prepared on Contractor's letterhead, record relevant information, requests for data, revisions other than those requested by Architect on previous submittals, and deviations from requirements in the Contract Documents, including minor variations and limitations. Include same identification information as related submittal.

J. Resubmittals: Make resubmittals in same form and number of copies as initial submittal.

1. Note date and content of previous submittal.
2. Note date and content of revision in label or title block and clearly indicate extent of revision.
3. Resubmit submittals until they are marked with approval notation from Architect's action stamp.

K. Distribution: Furnish copies of final submittals to manufacturers, subcontractors, suppliers, fabricators, installers, authorities having jurisdiction, and others as necessary for performance of construction activities. Show distribution on transmittal forms.

L. Use for Construction: Use only final submittals that are marked with approval notation from Architect's action stamp.

PART 2 - PRODUCTS

2.01 SUBMITTAL PROCEDURES

A. General Submittal Procedure Requirements:

1. Submit electronic submittals via email as PDF electronic files.

    a. Architect will return annotated file. Annotate and retain one copy of file as an electronic Project record document file.

2. Action Submittals: Submit three paper copies of each submittal, unless otherwise indicated. Architect will return two copies.
3. Informational Submittals: Submit two paper copies of each submittal, unless otherwise indicated. Architect will not return copies.
4. Closeout Submittals and Maintenance Material Submittals: Comply with requirements specified in Division 01 Section "Closeout Procedures."
5. Certificates and Certifications Submittals: Provide a statement that includes signature of entity responsible for preparing certification. Certificates and certifications shall be signed by an officer or other individual authorized to sign documents on behalf of that entity.

    a. Provide a digital signature with digital certificate on electronically-submitted certificates and certifications where indicated.
    b. Provide a notarized statement on original paper copy certificates and certifications where indicated.

6. Test and Inspection Reports Submittals: Comply with requirements specified in Division 01 Section "Quality Requirements."

B. Product Data: Collect information into a single submittal for each element of construction and type of product or equipment.

1. If information must be specially prepared for submittal because standard published data are not suitable for use, submit as Shop Drawings, not as Product Data.
2. Mark each copy of each submittal to show which products and options are applicable.
3. Include the following information, as applicable:

    a. Manufacturer's catalog cuts.
    b. Manufacturer's product specifications.
    c. Standard color charts.
    d. Statement of compliance with specified referenced standards.
    e. Testing by recognized testing agency.
    f. Application of testing agency labels and seals.
    g. Notation of coordination requirements.
    h. Availability and delivery time information.

4. For equipment, include the following in addition to the above, as applicable:

    a. Wiring diagrams showing factory-installed wiring.
    b. Printed performance curves.
    c. Operational range diagrams.

d. Clearances required to other construction, if not indicated on accompanying Shop Drawings.

5. Submit Product Data before or concurrent with Samples.
6. Submit Product Data in the following format:

a. PDF electronic file.

C. Shop Drawings: Prepare Project-specific information, drawn accurately to scale. Do not base Shop Drawings on reproductions of the Contract Documents or standard printed data.

1. Preparation: Fully illustrate requirements in the Contract Documents. Include the following information, as applicable:

a. Identification of products.
b. Schedules.
c. Compliance with specified standards.
d. Notation of coordination requirements.
e. Notation of dimensions established by field measurement.
f. Relationship and attachment to adjoining construction clearly indicated.
g. Seal and signature of professional engineer if specified.

2. Sheet Size: Except for templates, patterns, and similar full-size drawings, submit Shop Drawings on sheets at least 8-1/2 by 11 inches but no larger than 30 by 42 inches.
3. Submit Shop Drawings in the following format:

a. PDF electronic file.

D. Samples: Submit Samples for review of kind, color, pattern, and texture for a check of these characteristics with other elements and for a comparison of these characteristics between submittal and actual component as delivered and installed.

1. Transmit Samples that contain multiple, related components such as accessories together in one submittal package.
2. Identification: Attach label on unexposed side of Samples that includes the following:

a. Generic description of Sample.
b. Product name and name of manufacturer.
c. Sample source.
d. Number and title of applicable Specification Section.

3. Disposition: Maintain sets of approved Samples at Project site, available for quality-control comparisons throughout the course of construction activity. Sample sets may be used to determine final acceptance of construction associated with each set.

a. Samples that may be incorporated into the Work are indicated in individual Specification Sections. Such Samples must be in an undamaged condition at time of use.
b. Samples not incorporated into the Work, or otherwise designated as Owner's property, are the property of Contractor.

4. Samples for Initial Selection: Submit manufacturer's color charts consisting of units or sections of units showing the full range of colors, textures, and patterns available.

    a. Number of Samples: Submit one full set(s) of available choices where color, pattern, texture, or similar characteristics are required to be selected from manufacturer's product line. Architect will return submittal with options selected.

5. Samples for Verification: Submit full-size units or Samples of size indicated, prepared from same material to be used for the Work, cured and finished in manner specified, and physically identical with material or product proposed for use, and that show full range of color and texture variations expected. Samples include, but are not limited to, the following: partial sections of manufactured or fabricated components; small cuts or containers of materials; complete units of repetitively used materials; swatches showing color, texture, and pattern; color range sets; and components used for independent testing and inspection.

    a. Number of Samples: Submit three sets of Samples. Architect will retain two Sample sets; remainder will be returned. Mark up and retain one returned Sample set as a Project record sample.

        1) If variation in color, pattern, texture, or other characteristic is inherent in material or product represented by a Sample, submit at least three sets of paired units that show approximate limits of variations.

E. Product Schedule: As required in individual Specification Sections, prepare a written summary indicating types of products required for the Work and their intended location. Include the following information in tabular form:

1. Submit product schedule in the following format:

    a. PDF electronic file.

F. Contractor's Construction Schedule: Comply with requirements specified in Division 01 Section "Construction Progress Documentation."

G. Application for Payment: Comply with requirements specified in Division 01 Section "Payment Procedures."

H. Schedule of Values: Comply with requirements specified in Division 01 Section "Payment Procedures."

I. Subcontract List: Prepare a written summary identifying individuals or firms proposed for each portion of the Work, including those who are to furnish products or equipment fabricated to a special design.

1. Submit subcontract list in the following format:

    a. PDF electronic file.

J. Coordination Drawings: Comply with requirements specified in Division 01 Section "Project Management and Coordination."

K. Qualification Data: Prepare written information that demonstrates capabilities and experience of firm or person. Include lists of completed projects with project names and addresses, contact information of architects and owners, and other information specified.

L. Welding Certificates: Prepare written certification that welding procedures and personnel comply with requirements in the Contract Documents. Submit record of Welding Procedure Specification and Procedure Qualification Record on American Welding Society (AWS) forms. Include names of firms and personnel certified.

M. Installer Certificates: Submit written statements on manufacturer's letterhead certifying that Installer complies with requirements in the Contract Documents and, where required, is authorized by manufacturer for this specific Project.

N. Manufacturer Certificates: Submit written statements on manufacturer's letterhead certifying that manufacturer complies with requirements in the Contract Documents. Include evidence of manufacturing experience where required.

O. Product Certificates: Submit written statements on manufacturer's letterhead certifying that product complies with requirements in the Contract Documents.

P. Material Certificates: Submit written statements on manufacturer's letterhead certifying that material complies with requirements in the Contract Documents.

Q. Material Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting test results of material for compliance with requirements in the Contract Documents.

R. Product Test Reports: Submit written reports indicating current product produced by manufacturer complies with requirements in the Contract Documents. Base reports on evaluation of tests performed by manufacturer and witnessed by a qualified testing agency, or on comprehensive tests performed by a qualified testing agency.

S. Research Reports: Submit written evidence, from a model code organization acceptable to authorities having jurisdiction, that product complies with building code in effect for Project.

T. Schedule of Tests and Inspections: Comply with requirements specified in Division 01 Section "Quality Requirements."

U. Preconstruction Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of tests performed before installation of product, for compliance with performance requirements in the Contract Documents.

V. Compatibility Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of compatibility tests performed before installation of product. Include written recommendations for primers and substrate preparation needed for adhesion.

W. Field Test Reports: Submit reports indicating and interpreting results of field tests performed either during installation of product or after product is installed in its final location, for compliance with requirements in the Contract Documents.

X. Maintenance Data: Comply with requirements specified in Division 01 Section "Operation and Maintenance Data."

Y. Design Data: Prepare and submit written and graphic information, including, but not limited to, performance and design criteria, list of applicable codes and regulations, and calculations. Include list of assumptions and other performance and design criteria and a summary of loads. Include load diagrams if applicable. Provide name and version of software, if any, used for calculations. Include page numbers.

2.02 DELEGATED-DESIGN SERVICES

A. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.

1. If criteria indicated are not sufficient to perform services or certification required, submit a written request for additional information to Architect.

B. Delegated-Design Services Certification: In addition to Shop Drawings, Product Data, and other required submittals, submit digitally-signed PDF electronic file and three paper copies of certificate, signed and sealed by the responsible design professional, for each product and system specifically assigned to Contractor to be designed or certified by a design professional.

1. Indicate that products and systems comply with performance and design criteria in the Contract Documents. Include list of codes, loads, and other factors used in performing these services.

PART 3 - EXECUTION

3.01 CONTRACTOR'S REVIEW

A. Action and Informational Submittals: Review each submittal and check for coordination with other Work of the Contract and for compliance with the Contract Documents. Note corrections and field dimensions. Mark with approval stamp before submitting to Architect.

B. Project Closeout and Maintenance/Material Submittals: Refer to requirements in Division 01 Section "Closeout Procedures."

C. Approval Stamp: Stamp each submittal with a uniform, approval stamp. Include Project name and location, submittal number, Specification Section title and number, name of reviewer, date of Contractor's approval, and statement certifying that submittal has been reviewed, checked, and approved for compliance with the Contract Documents.

3.02 ARCHITECT'S ACTION

A. General: Architect will not review submittals that do not bear Contractor's approval stamp and will return them without action.

B. Action Submittals: Architect will review each submittal, make marks to indicate corrections or modifications required, and return it. Architect will stamp each submittal with an action stamp and will mark stamp appropriately to indicate action.

C. Informational Submittals: Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.

D. Incomplete submittals are not acceptable, will be considered nonresponsive, and will be returned without review.

E. Submittals not required by the Contract Documents may not be reviewed and may be discarded.

END OF SECTION 01 33 00

SECTION 01 77 00

CLOSEOUT PROCEDURES

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes administrative and procedural requirements for contract closeout, including, but not limited to, the following:

1. Substantial Completion procedures.
2. Final completion procedures.
3. Warranties.
4. Final cleaning.

B. Related Sections:

1. Division 01 Section "Operation and Maintenance Data" for operation and maintenance manual requirements.
2. Division 01 Section "Project Record Documents" for submitting Record Drawings, Record Specifications, and Record Product Data.
3. Division 01 Section "Demonstration and Training" for requirements for instructing Owner's personnel.
4. Divisions 02 through 49 Sections for specific closeout and special cleaning requirements for the Work in those Sections.

1.02 SUBSTANTIAL COMPLETION

A. Preliminary Procedures: Before requesting inspection for determining date of Substantial Completion, complete the following. List items below that are incomplete with request.

1. Prepare a list of items to be completed and corrected (punch list), the value of items on the list, and reasons why the Work is not complete.
2. Advise Owner of pending insurance changeover requirements.
3. Submit specific warranties, workmanship bonds, maintenance service agreements, final certifications, and similar documents.
4. Obtain and submit releases permitting Owner unrestricted use of the Work and access to services and utilities. Include occupancy permits, operating certificates, and similar releases.
5. Prepare and submit Project Record Documents, operation and maintenance manuals, final completion construction photographic documentation, damage or settlement surveys, property surveys, and similar final record information.
6. Deliver tools, spare parts, extra materials, and similar items to location designated by Owner. Label with manufacturer's name and model number where applicable.
7. Make final changeover of permanent locks and deliver keys to Owner. Advise Owner's personnel of changeover in security provisions.
8. Complete startup testing of systems.
9. Submit test/adjust/balance records.
10. Terminate and remove temporary facilities from Project site, along with mockups, construction tools, and similar elements.
11. Advise Owner of changeover in heat and other utilities.
12. Submit changeover information related to Owner's occupancy, use, operation, and maintenance.

13. Complete final cleaning requirements, including touchup painting.
14. Touch up and otherwise repair and restore marred exposed finishes to eliminate visual defects.

B. Inspection: Submit a written request for inspection for Substantial Completion. On receipt of request, Architect will either proceed with inspection or notify Contractor of unfulfilled requirements. Architect will prepare the Certificate of Substantial Completion after inspection or will notify Contractor of items, either on Contractor's list or additional items identified by Architect, that must be completed or corrected before certificate will be issued.

1. Reinspection: Request reinspection when the Work identified in previous inspections as incomplete is completed or corrected.
2. Results of completed inspection will form the basis of requirements for final completion.

C. Each phase shall have its own substantial completion after punch list have been completed and equipment is fully operational. The substantial completion dates shall correspond with the unit startup dates.

1.03 FINAL COMPLETION

A. Preliminary Procedures: Before requesting final inspection for determining final completion, complete the following:

1. Submit a final Application for Payment.
2. Submit certified copy of Architect's Substantial Completion inspection list of items to be completed or corrected (punch list), endorsed and dated by Architect. The certified copy of the list shall state that each item has been completed or otherwise resolved for acceptance.
3. Submit evidence of final, continuing insurance coverage complying with insurance requirements.
4. Instruct Owner's personnel in operation, adjustment, and maintenance of products, equipment, and systems. Submit demonstration and training video recordings.

B. Inspection: Submit a written request for final inspection for acceptance. On receipt of request, Architect will either proceed with inspection or notify Contractor of unfulfilled requirements. Architect will prepare a final Certificate for Payment after inspection or will notify Contractor of construction that must be completed or corrected before certificate will be issued.

1. Reinspection: Request reinspection when the Work identified in previous inspections as incomplete is completed or corrected.

1.04 LIST OF INCOMPLETE ITEMS (PUNCH LIST)

A. Organization of List: Include name and identification of each space and area affected by construction operations for incomplete items and items needing correction including, if necessary, areas disturbed by Contractor that are outside the limits of construction.

1. Organize list of spaces in sequential order.
2. Organize items applying to each space by major element, including categories for ceiling, individual walls, floors, equipment, and building systems.
3. Submit list of incomplete items in the following format:

a. PDF electronic file.

1.05 WARRANTIES

A. Submittal Time: Submit written warranties on request of Architect for designated portions of the Work where commencement of warranties other than date of each phases' Substantial Completion is indicated.

B. General Warranty: General Contractor to provide one-year comprehensive parts and labor warranty for all equipment installed under Contract Documents. Warranty to begin on date of Substantial Completion and include expiration date. General Warranty letter to be incorporated into warranty documents in Project Manual.

C. Organize warranty documents into an orderly sequence based on the table of contents of the Project Manual.

1. Bind warranties and bonds in heavy-duty, 3-ring, vinyl-covered, loose-leaf binders, thickness as necessary to accommodate contents, and sized to receive 8-1/2-by-11-inch paper.
2. Provide heavy paper dividers with plastic-covered tabs for each separate warranty. Mark tab to identify the product or installation. Provide a typed description of the product or installation, including the name of the product and the name, address, and telephone number of Installer.
3. Identify each binder on the front and spine with the typed or printed title "WARRANTIES," Project name, and name of Contractor.
4. Scan warranties and bonds and assemble complete warranty and bond submittal package into a single indexed electronic PDF file with links enabling navigation to each item. Provide table of contents at beginning of document.

D. Provide additional copies of each warranty to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Cleaning Agents: Use cleaning materials and agents recommended by manufacturer or fabricator of the surface to be cleaned. Do not use cleaning agents that are potentially hazardous to health or property or that might damage finished surfaces.

1. Use cleaning products that meet Green Seal GS-37, or if GS-37 is not applicable, use products that comply with the California Code of Regulations maximum allowable VOC levels.

PART 3 - EXECUTION

3.01 FINAL CLEANING

A. General: Perform final cleaning. Conduct cleaning and waste-removal operations to comply with local laws and ordinances and Federal and local environmental and antipollution regulations.

B. Cleaning: Employ experienced workers or professional cleaners for final cleaning. Clean each surface or unit to condition expected in an average commercial building cleaning and maintenance program. Comply with manufacturer's written instructions.

1. Complete the following cleaning operations before requesting inspection for certification of Substantial Completion for entire Project or for a portion of Project:

   a. Clean Project site, yard, and grounds, in areas disturbed by construction activities, including landscape development areas, of rubbish, waste material, litter, and other foreign substances.
   b. Sweep paved areas broom clean. Remove petrochemical spills, stains, and other foreign deposits.
   c. Rake grounds that are neither planted nor paved to a smooth, even-textured surface.
   d. Remove tools, construction equipment, machinery, and surplus material from Project site.
   e. Clean exposed exterior and interior hard-surfaced finishes to a dirt-free condition, free of stains, films, and similar foreign substances. Avoid disturbing natural weathering of exterior surfaces. Restore reflective surfaces to their original condition.
   f. Remove debris and surface dust from limited access spaces, including roofs, plenums, shafts, trenches, equipment vaults, manholes, attics, and similar spaces.
   g. Sweep concrete floors broom clean in unoccupied spaces.
   h. Vacuum carpet and similar soft surfaces, removing debris and excess nap; shampoo if visible soil or stains remain.
   i. Clean transparent materials, including mirrors and glass in doors and windows. Remove glazing compounds and other noticeable, vision-obscuring materials. Replace chipped or broken glass and other damaged transparent materials. Polish mirrors and glass, taking care not to scratch surfaces.
   j. Remove labels that are not permanent.
   k. Touch up and otherwise repair and restore marred, exposed finishes and surfaces. Replace finishes and surfaces that cannot be satisfactorily repaired or restored or that already show evidence of repair or restoration.

      1) Do not paint over "UL" and other required labels and identification, including mechanical and electrical nameplates.

   l. Wipe surfaces of mechanical and electrical equipment and similar equipment. Remove excess lubrication, paint and mortar droppings, and other foreign substances.
   m. Replace parts subject to operating conditions during construction that may impede operation or reduce longevity.
   n. Replace disposable air filters and clean permanent air filters. Clean exposed surfaces of diffusers, registers, and grills.
   o. Clean light fixtures, lamps, globes, and reflectors to function with full efficiency. Replace burned-out bulbs, and those noticeably dimmed by hours of use, and defective and noisy starters in fluorescent and mercury vapor fixtures to comply with requirements for new fixtures.
   p. Leave Project clean and ready for occupancy.

END OF SECTION 01 77 00

SECTION 01 78 23

OPERATION AND MAINTENANCE DATA

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes administrative and procedural requirements for preparing operation and maintenance manuals, including the following:

1. Operation and maintenance documentation directory.
2. Emergency manuals.
3. Operation manuals for systems, subsystems, and equipment.
4. Product maintenance manuals.
5. Systems and equipment maintenance manuals.

B. Related Sections:

1. Divisions 02 through 49 Sections for specific operation and maintenance manual requirements for the Work in those Sections.

1.02 CLOSEOUT SUBMITTALS

A. Format: Submit operations and maintenance manuals in the following format:

1. PDF electronic file. Assemble each manual into a composite electronically-indexed file. Submit on digital media acceptable to Architect.

a. Name each indexed document file in composite electronic index with applicable item name. Include a complete electronically-linked operation and maintenance directory.
b. Enable inserted reviewer comments on draft submittals.

AND

2. Three paper copies. Include a complete operation and maintenance directory. Enclose title pages and directories in clear plastic sleeves. Contractor shall deliver 3 completed copies to the owner.

B. Manual Submittal: Submit each manual in final form prior to requesting inspection for Substantial Completion and at least 15 days before commencing demonstration and training. Architect will return copy with comments.

1. Correct or modify each manual to comply with Architect's comments. Submit copies of each corrected manual within 15 days of receipt of Architect's comments and prior to commencing demonstration and training.

PART 2 - PRODUCTS

2.01 REQUIREMENTS FOR EMERGENCY, OPERATION, AND MAINTENANCE MANUALS

A. Organization: Unless otherwise indicated, organize each manual into a separate section for each system and subsystem, and a separate section for each piece of equipment not part of a system. Each manual shall contain the following materials, in the order listed:

1. Title page.
2. Table of contents.
3. Manual contents.

B. Title Page: Include the following information:

1. Subject matter included in manual.
2. Name and address of Project.
3. Name and address of Owner.
4. Date of submittal.
5. Name and contact information for Contractor.
6. Name and contact information for Construction Manager.
7. Name and contact information for Architect.
8. Name and contact information for Commissioning Agent.
9. Names and contact information for major consultants to the Architect that designed the systems contained in the manuals.
10. Cross-reference to related systems in other operation and maintenance manuals.

C. Table of Contents: List each product included in manual, identified by product name, indexed to the content of the volume, and cross-referenced to Specification Section number in Project Manual.

D. Manual Contents: Organize into sets of manageable size. Arrange contents alphabetically by system, subsystem, and equipment. If possible, assemble instructions for subsystems, equipment, and components of one system into a single binder.

E. Manuals, Electronic Files: Submit manuals in the form of a multiple file composite electronic PDF file for each manual type required.

1. Electronic Files: Use electronic files prepared by manufacturer where available. Where scanning of paper documents is required, configure scanned file for minimum readable file size.
2. File Names and Bookmarks: Enable bookmarking of individual documents based upon file names. Name document files to correspond to system, subsystem, and equipment names used in manual directory and table of contents. Group documents for each system and subsystem into individual composite bookmarked files, then create composite manual, so that resulting bookmarks reflect the system, subsystem, and equipment names in a readily navigated file tree. Configure electronic manual to display bookmark panel upon opening file.

F. Manuals, Paper Copy: Submit manuals in the form of hard copy, bound and labeled volumes.

1. Binders: Heavy-duty, three-ring, vinyl-covered, loose-leaf binders, maximum thickness of 3-1/2”, sized to hold 8-1/2-by-11-inch paper; with clear plastic sleeve on spine and front cover to hold label describing contents and with pockets inside covers to hold folded oversize sheets.

    a. Identify each binder on front and spine, with printed title "OPERATION AND MAINTENANCE MANUAL," Project title or name, subject matter of contents, and indicate Specification Section number on bottom of spine. Indicate volume number for multiple-volume sets.

2. Dividers: Heavy-paper dividers with plastic-covered tabs for each section of the manual. Mark each tab to indicate contents. Include typed list of products and

major components of equipment included in the section on each divider, cross-referenced to Specification Section number and title of Project Manual.

3. Protective Plastic Sleeves: Transparent plastic sleeves designed to enclose diagnostic software storage media for computerized electronic equipment.
4. Drawings: Attach reinforced, punched binder tabs on drawings and bind with text.

    a. If oversize drawings are necessary, fold drawings to same size as text pages and use as foldouts.
    b. If drawings are too large to be used as foldouts, fold and place drawings in labeled envelopes and bind envelopes in rear of manual. At appropriate locations in manual, insert typewritten pages indicating drawing titles, descriptions of contents, and drawing locations.

2.02 EMERGENCY MANUALS

A. Content: Organize manual into a separate section for each of the following:

1. Type of emergency.
2. Emergency instructions.
3. Emergency procedures.

B. Type of Emergency: Where applicable for each type of emergency indicated below, include instructions and procedures for each system, subsystem, piece of equipment, and component:

1. Fire.
2. Flood.
3. Gas leak.
4. Water leak.
5. Power failure.
6. Water outage.
7. System, subsystem, or equipment failure.
8. Chemical release or spill.

C. Emergency Instructions: Describe and explain warnings, trouble indications, error messages, and similar codes and signals. Include responsibilities of Owner's operating personnel for notification of Installer, supplier, and manufacturer to maintain warranties.

D. Emergency Procedures: Include the following, as applicable:

1. Instructions on stopping.
2. Shutdown instructions for each type of emergency.
3. Operating instructions for conditions outside normal operating limits.
4. Required sequences for electric or electronic systems.
5. Special operating instructions and procedures.

2.03 OPERATION MANUALS

A. Content: In addition to requirements in this Section, include operation data required in individual Specification Sections and the following information:

1. System, subsystem, and equipment descriptions. Use designations for systems and equipment indicated on Contract Documents.
2. Performance and design criteria if Contractor is delegated design responsibility.

3. Operating standards.
4. Operating procedures.
5. Operating logs.
6. Wiring diagrams.
7. Control diagrams.
8. Piped system diagrams.
9. Precautions against improper use.
10. License requirements including inspection and renewal dates.

B. Descriptions: Include the following:

1. Product name and model number. Use designations for products indicated on Contract Documents.
2. Manufacturer's name.
3. Equipment identification with serial number of each component.
4. Equipment function.
5. Operating characteristics.
6. Limiting conditions.
7. Performance curves.
8. Engineering data and tests.
9. Complete nomenclature and number of replacement parts.

C. Operating Procedures: Include the following, as applicable:

1. Startup procedures.
2. Equipment or system break-in procedures.
3. Routine and normal operating instructions.
4. Regulation and control procedures.
5. Instructions on stopping.
6. Normal shutdown instructions.
7. Seasonal and weekend operating instructions.
8. Required sequences for electric or electronic systems.
9. Special operating instructions and procedures.

D. Systems and Equipment Controls: Describe the sequence of operation, and diagram controls as installed.

E. Piped Systems: Diagram piping as installed, and identify color-coding where required for identification.

2.04 PRODUCT MAINTENANCE MANUALS

A. Content: Organize manual into a separate section for each product, material, and finish. Include source information, product information, maintenance procedures, repair materials and sources, and warranties and bonds, as described below.

B. Source Information: List each product included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual.

C. Product Information: Include the following, as applicable:

1. Product name and model number.
2. Manufacturer's name.

3. Color, pattern, and texture.
4. Material and chemical composition.
5. Reordering information for specially manufactured products.

D. Maintenance Procedures: Include manufacturer's written recommendations and the following:

1. Inspection procedures.
2. Types of cleaning agents to be used and methods of cleaning.
3. List of cleaning agents and methods of cleaning detrimental to product.
4. Schedule for routine cleaning and maintenance.
5. Repair instructions.

E. Repair Materials and Sources: Include lists of materials and local sources of materials and related services.

F. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.

2.05 SYSTEMS AND EQUIPMENT MAINTENANCE MANUALS

A. Content: For each system, subsystem, and piece of equipment not part of a system, include source information, manufacturers' maintenance documentation, maintenance procedures, maintenance and service schedules, spare parts list and source information, maintenance service contracts, and warranty and bond information, as described below.

B. Source Information: List each system, subsystem, and piece of equipment included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual.

C. Manufacturers' Maintenance Documentation: Manufacturers' maintenance documentation including the following information for each component part or piece of equipment:

1. Standard maintenance instructions and bulletins.
2. Drawings, diagrams, and instructions required for maintenance, including disassembly and component removal, replacement, and assembly.
3. Identification and nomenclature of parts and components.
4. List of items recommended to be stocked as spare parts.

D. Maintenance Procedures: Include the following information and items that detail essential maintenance procedures:

1. Test and inspection instructions.
2. Troubleshooting guide.
3. Precautions against improper maintenance.
4. Disassembly; component removal, repair, and replacement; and reassembly instructions.
5. Aligning, adjusting, and checking instructions.
6. Demonstration and training video recording, if available.

E. Maintenance and Service Schedules: Include service and lubrication requirements, list of required lubricants for equipment, and separate schedules for preventive and routine maintenance and service with standard time allotment.

F. Spare Parts List and Source Information: Include lists of replacement and repair parts, with parts identified and cross-referenced to manufacturers' maintenance documentation and local sources of maintenance materials and related services.

G. Maintenance Service Contracts: Include copies of maintenance agreements with name and telephone number of service agent.

H. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.

PART 3 - EXECUTION

3.01 MANUAL PREPARATION

A. Emergency Manual: Assemble a complete set of emergency information indicating procedures for use by emergency personnel and by Owner's operating personnel for types of emergencies indicated.

B. Product Maintenance Manual: Assemble a complete set of maintenance data indicating care and maintenance of each product, material, and finish incorporated into the Work.

C. Operation and Maintenance Manuals: Assemble a complete set of operation and maintenance data indicating operation and maintenance of each system, subsystem, and piece of equipment not part of a system.

D. Manufacturers' Data: Where manuals contain manufacturers' standard printed data, include only sheets pertinent to product or component installed. Mark each sheet to identify each product or component incorporated into the Work. If data include more than one item in a tabular format, identify each item using appropriate references from the Contract Documents. Identify data applicable to the Work and delete references to information not applicable.

E. Drawings: Prepare drawings supplementing manufacturers' printed data to illustrate the relationship of component parts of equipment and systems and to illustrate control sequence and flow diagrams. Coordinate these drawings with information contained in record Drawings to ensure correct illustration of completed installation.

1. Do not use original project record documents as part of operation and maintenance manuals.

F. Comply with Division 01 Section "Closeout Procedures" for schedule for submitting operation and maintenance documentation.

END OF SECTION 01 78 23

SECTION 01 78 39

PROJECT RECORD DOCUMENTS

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes administrative and procedural requirements for project record documents, including the following:

1. Record Drawings.

B. Related Sections:

1. Division 01 Section "Operation and Maintenance Data" for operation and maintenance manual requirements.
2. Divisions 02 through 49 Sections for specific requirements for project record documents of the Work in those Sections.

1.02 CLOSEOUT SUBMITTALS

A. Record Drawings: Comply with the following:

1. Number of Copies: Submit one set(s) of marked-up record prints.
2. Number of Copies: Submit copies of record Drawings as follows:

a. Initial Submittal: Submit one paper copy set and one PDF electronic files of marked-up record prints and one set(s) of plots from corrected record digital data files. Architect will indicate whether general scope of changes, additional information recorded, and quality of drafting are acceptable.
b. Final Submittal: Submit one paper copy set and one PDF electronic files of marked-up record prints. Print each Drawing, whether or not changes and additional information were recorded.

PART 2 - PRODUCTS

2.01 RECORD DRAWINGS

A. Record Prints: Maintain one set of marked-up paper copies of the Contract Drawings and Shop Drawings.

1. Preparation: Mark record prints to show the actual installation where installation varies from that shown originally. Require individual or entity who obtained record data, whether individual or entity is Installer, subcontractor, or similar entity, to provide information for preparation of corresponding marked-up record prints.

a. Give particular attention to information on concealed elements that would be difficult to identify or measure and record later.
b. Record data as soon as possible after obtaining it.
c. Record and check the markup before enclosing concealed installations.

2. Mark the Contract Drawings and Shop Drawings completely and accurately. Utilize personnel proficient at recording graphic information in production of marked-up record prints.
3. Mark record sets with erasable, red-colored pencil. Use other colors to distinguish between changes for different categories of the Work at same location.
4. Note Construction Change Directive numbers, alternate numbers, Change Order numbers, and similar identification, where applicable.

B. Format: Identify and date each record Drawing; include the designation "PROJECT RECORD DRAWING" in a prominent location.

1. Record Prints: Organize record prints and newly prepared record Drawings into manageable sets. Bind each set with durable paper cover sheets. Include identification on cover sheets.
2. Format: Annotated PDF electronic file.
3. Identification: As follows:

a. Project name.
b. Date.
c. Designation "PROJECT RECORD DRAWINGS."
d. Name of Architect.
e. Name of Contractor.

2.02 MISCELLANEOUS RECORD SUBMITTALS

A. Assemble miscellaneous records required by other Specification Sections for miscellaneous record keeping and submittal in connection with actual performance of the Work. Bind or file miscellaneous records and identify each, ready for continued use and reference.

B. Format: Submit miscellaneous record submittals as PDF electronic file and paper copy.

PART 3 - EXECUTION

3.01 RECORDING AND MAINTENANCE

A. Recording: Maintain one copy of each submittal during the construction period for project record document purposes. Post changes and modifications to project record documents as they occur; do not wait until the end of Project.

B. Maintenance of Record Documents and Samples: Store record documents and Samples in the field office apart from the Contract Documents used for construction. Do not use project record documents for construction purposes. Maintain record documents in good order and in a clean, dry, legible condition, protected from deterioration and loss. Provide access to project record documents for Architect's reference during normal working hours.

END OF SECTION 01 78 39

SECTION 01 79 00

DEMONSTRATION AND TRAINING

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes administrative and procedural requirements for instructing Owner's personnel, including the following:

1. Demonstration of operation of systems, subsystems, and equipment.
2. Training in operation and maintenance of systems, subsystems, and equipment.
3. Demonstration and training video recordings.

1.02 INFORMATIONAL SUBMITTALS

A. Instruction Program: Submit outline of instructional program for demonstration and training, including a list of training modules and a schedule of proposed dates, times, length of instruction time, and instructors' names for each training module. Include learning objective and outline for each training module.

1. Indicate proposed training modules utilizing manufacturer-produced demonstration and training video recordings for systems, equipment, and products in lieu of video recording of live instructional module.

B. Owner Training Documentation – Include items such as:

1. Written instructions and videos documenting startup
2. Shutdown
3. Adjustments
4. Emergency procedures
5. Regular required maintenance items.

C. Owner training shall be performed on all equipment and systems including controls. Training times shall be coordinated with the owner and done after systems are operational.

1. Control systems shall have a minimum of (2) separate 4-hour sessions included to be scheduled at the owner’s convenience.

1.03 CLOSEOUT SUBMITTALS

A. Demonstration and Training Video Recordings: Submit two copies within seven days of end of each training module.

1. At completion of training, submit complete training manual(s) for Owner's use.

1.04 QUALITY ASSURANCE

A. Facilitator Qualifications: A firm or individual experienced in training or educating maintenance personnel in a training program similar in content and extent to that indicated for this Project, and whose work has resulted in training or education with a record of successful learning performance.

B. Instructor Qualifications: A factory-authorized service representative, experienced in operation and maintenance procedures and training.

C. Preinstruction Conference: Conduct conference at Project site to comply with requirements in Division 01 Sections. Review methods and procedures related to demonstration and training.

1.05 COORDINATION

A. Coordinate instruction schedule with Owner's operations. Adjust schedule as required to minimize disrupting Owner's operations.

B. Coordinate content of training modules with content of approved emergency, operation, and maintenance manuals. Do not submit instruction program until operation and maintenance data has been reviewed and approved by Architect.

PART 2 - PRODUCTS

2.01 INSTRUCTION PROGRAM

A. Program Structure: Develop an instruction program that includes individual training modules for each system and for equipment not part of a system, as required by individual Specification Sections.

B. Training Modules: Develop a learning objective and teaching outline for each module. Include a description of specific skills and knowledge that participant is expected to master. For each module, include instruction for the following as applicable to the system, equipment, or component:

1. Basis of System Design, Operational Requirements, and Criteria: Include the following:

    a. System, subsystem, and equipment descriptions.
    b. Performance and design criteria if Contractor is delegated design responsibility.
    c. Operating standards.
    d. Regulatory requirements.
    e. Equipment function.
    f. Operating characteristics.
    g. Limiting conditions.
    h. Performance curves.

2. Documentation: Review the following items in detail:

    a. Emergency manuals.
    b. Operations manuals.
    c. Maintenance manuals.
    d. Project record documents.
    e. Identification systems.
    f. Warranties and bonds.
    g. Maintenance service agreements and similar continuing commitments.

3. Emergencies: Include the following, as applicable:

a. Instructions on meaning of warnings, trouble indications, and error messages.
b. Instructions on stopping.
c. Shutdown instructions for each type of emergency.
d. Operating instructions for conditions outside of normal operating limits.
e. Sequences for electric or electronic systems.
f. Special operating instructions and procedures.

4. Operations: Include the following, as applicable:

a. Startup procedures.
b. Equipment or system break-in procedures.
c. Routine and normal operating instructions.
d. Regulation and control procedures.
e. Control sequences.
f. Safety procedures.
g. Instructions on stopping.
h. Normal shutdown instructions.
i. Operating procedures for emergencies.
j. Operating procedures for system, subsystem, or equipment failure.
k. Seasonal and weekend operating instructions.
l. Required sequences for electric or electronic systems.
m. Special operating instructions and procedures.

5. Adjustments: Include the following:

a. Alignments.
b. Checking adjustments.
c. Noise and vibration adjustments.
d. Economy and efficiency adjustments.

6. Troubleshooting: Include the following:

a. Diagnostic instructions.
b. Test and inspection procedures.

7. Maintenance: Include the following:

a. Inspection procedures.
b. Types of cleaning agents to be used and methods of cleaning.
c. List of cleaning agents and methods of cleaning detrimental to product.
d. Procedures for routine cleaning
e. Procedures for preventive maintenance.
f. Procedures for routine maintenance.
g. Instruction on use of special tools.

8. Repairs: Include the following:

a. Diagnosis instructions.
b. Repair instructions.
c. Disassembly; component removal, repair, and replacement; and reassembly instructions.
d. Instructions for identifying parts and components.
e. Review of spare parts needed for operation and maintenance.

PART 3 - EXECUTION

3.01 PREPARATION

A. Assemble educational materials necessary for instruction, including documentation and training module. Assemble training modules into a training manual organized in coordination with requirements in Division 01 Section "Operations and Maintenance Data."

3.02 INSTRUCTION

A. Facilitator: Engage a qualified facilitator to prepare instruction program and training modules, to coordinate instructors, and to coordinate between Contractor and Owner for number of participants, instruction times, and location.

B. Engage qualified instructors to instruct Owner's personnel to adjust, operate, and maintain systems, subsystems, and equipment not part of a system.

1. Architect will furnish an instructor to describe basis of system design, operational requirements, criteria, and regulatory requirements.
2. Owner will furnish an instructor to describe Owner's operational philosophy.
3. Owner will furnish Contractor with names and positions of participants.

C. Scheduling: Provide instruction at mutually agreed on times. For equipment that requires seasonal operation, provide similar instruction at start of each season.

1. Schedule training with Owner with at least seven days' advance notice.
2. Provide minimum four (4) hours training on systems in at least two (2) separate segments. In addition provide separately minimum eight (8) hours training on control systems in at least four (4) separate segments.
3. Provide additional four (4) hour training sessions at 6 month after substantial completion and 11 months after substantial completion.

3.03 DEMONSTRATION AND TRAINING VIDEO RECORDINGS

A. General: Engage a qualified videographer to record demonstration and training video recordings. Record each training module separately. Include classroom instructions and demonstrations, board diagrams, and other visual aids, but not student practice.

1. At beginning of each training module, record each chart containing learning objective and lesson outline.

B. Video Recording Format: Provide high-quality color video recordings with menu navigation in format acceptable to Architect.

C. Narration: Describe scenes on video recording by audio narration by microphone while or dubbing audio narration off-site after video recording is recorded. Include description of items being viewed.

D. Pre-Produced Video Recordings: Provide video recordings used as a component of training modules in same format as recordings of live training.

END OF SECTION 01 79 00

SECTION 019113
GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. General requirements for coordinating and scheduling commissioning activities.
2. Commissioning meetings.
3. Commissioning reports.
4. Use of commissioning process test equipment, instrumentation, and tools.
5. Construction checklists, including, but not limited to, installation checks, startup, performance tests, and performance test demonstration.
6. Commissioning tests and commissioning test demonstration.
7. Adjusting, verifying, and documenting identified systems and assemblies.

B. Related Requirements:
1. Section 220800 "Commissioning of Plumbing" for technical commissioning requirements for plumbing.
2. Section 230800 "Commissioning of HVAC Requirements" for technical commissioning requirements for HVAC.
3. Section 260800 "Commissioning of Electrical Systems Requirements" for technical commissioning requirements for electrical systems.

1.2 DEFINITIONS

A. Acceptance Criteria: Threshold of acceptable work quality or performance specified for a commissioning activity, including, but not limited to, construction checklists, performance tests, performance test demonstrations, commissioning tests, and commissioning test demonstrations.

B. Commissioning Authority (CxA): An entity engaged by the Owner to define, review, perform and evaluate Commissioning-Process Work.
1. Advanced Engineering Systems (AES) is the Commissioning Authority.

C. Commissioning Contractor (CxC): A person or entity employed by Contractor to manage, schedule, and coordinate commissioning process

D. Commissioning Plan: A document, prepared by Commissioning Authority, that outlines the organization, schedule, allocation of resources, and documentation of commissioning requirements.

E. Commissioning Specifications: The written specifications that are include in the design documents (drawings and specifications) that describe the commissioning requirements and process to be followed during the contrition process.

F. Commissioning: A quality-focused process for verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, and tested to comply with Owner's Project Requirements. The requirements specified here are limited to the construction phase commissioning activities.

G. Construction-Phase Commissioning-Process Completion: The stage of completion and acceptance of commissioning process when resolution of deficient conditions and issues discovered during commissioning process and retesting until acceptable results are obtained has been accomplished. Owner will establish in writing the date construction-phase commissioning-process completion is achieved.
   1. Commissioning process is complete when the Work specified of this Section and related Sections has been completed and accepted, including, but not limited to, the following:
      a. Completion of tests and acceptance of test results.
      b. Resolution of issues, as verified by retests performed and documented with acceptance of retest results.
      c. Comply with all closeout documentation including providing Operation and Maintenance (O&M) data and owner training.
      d. Completion and acceptance of submittals and reports.

H. Contractor: The general contractor including all sub-contractors under contract to fulfill the contract documents.

I. Functional Performance Tests (FPTs): Tests design to ensure all equipment and systems respond and act as they are designed in different modes, circumstances and scenarios.

J. Owner's Witness: Commissioning Authority, Owner's Project Manager, or Architect-designated witness authorized to authenticate test demonstration data and to sign completed test data forms.

K. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they shall mean "as-built" systems, assemblies, subsystems, equipment, and components.

L. Test: Performance tests, performance test demonstrations, commissioning tests, and commissioning test demonstrations.

1.3 COMMISSIONING TEAM

A. Members Appointed by Contractor(s):
   1. Commissioning Coordinator (CxC): A person or entity employed by Contractor to manage, schedule, and coordinate commissioning process. The CxC shall be the main point of contact for the contractor including all subcontractors.
   2. Trade project superintendent and other employees that Contractor may deem appropriate for a particular portion of the commissioning process.
   3. Subcontractors, installers, suppliers, and specialists that Contractor may deem appropriate for a particular portion of the commissioning process.
   4. Appointed team members shall have the authority to act on behalf of the entity they represent.

B. Members Appointed by Owner:
   1. Commissioning Authority (CxA), plus consultants that Commissioning Authority may deem appropriate for a particular portion of the commissioning process.
   2. Owner representative(s), facility operations and maintenance personnel, plus other employees, separate contractors, and consultants that Owner may deem appropriate for a particular portion of the commissioning process.
   3. Architect, plus employees and consultants that Architect may deem appropriate for a particular portion of the commissioning process.

1.4 SUBMITTALS TO BE SUBMITTED BY CONTRACTOR – at the beginning of the construction phase.

A. Contractor Commissioning team / equipment Information:
   1. List of Contractor-appointed commissioning team members to include specific personnel and subcontractors performing the various commissioning requirements.
      a. Commissioning Coordinator Qualification Data: For entity coordinating Contractor's commissioning activities to demonstrate their capabilities and experience to including successfully completed past projects of similar size and scope, including experience with projects including commissioning and experience with the owner on previous projects.
   2. Contractor personnel and subcontractors participating in the commissioning process.
   3. List of instrumentation required for each test to include identification of parties that will provide instrumentation for each test. Include:
      a. Make, model, serial number, and application for each instrument, equipment, and monitoring device.
      b. Brief description of intended use.
      c. Calibration record showing the following:
         1) Calibration agency, including name and contact information.
         2) Last date of calibration.
         3) Range of values for which calibration is valid.
         4) Certification of accuracy.
         5) Certification for calibration equipment traceable to NIST.
         6) Due date of the next calibration.

B. Construction schedule.
   1. Schedule of commissioning activities, integrated with the Construction Schedule. Time allotted for commissioning shall be coordinated with the CxA for specific equipment and systems. Commissioning shall be included in the schedule before the final completion date
   2. Contractor shall provide two-week look-ahead schedules to keep the CxA updated as schedules adjust during construction.

C. Blank equipment start up reports.
   1. Blank start up reports to be submitted by the contractor for review by the CxA.
   2. Start up reports shall include the manufacturer’s recommended criteria and items as well as any additional information recommended by the contractor and required by the CxA.
   3. Reports shall include areas for equipment to be tested in all possible modes and ranges.
   4. Reports shall include what equipment is to be started with the use of each report including equipment type and tag information from the design documents.
   5. Reports shall be submitted for all scheduled equipment in the commissioning scope or as indicated by the CxA.

D. Blank test and balance (TAB) forms.
   1. Blank TAB forms to be submitted by the contractor for review by the CxA
   2. TAB reports to include TAB contractor qualifications and information on equipment to be used. Information on equipment to be used to include make, model, description and calibration history.
   3. Forms shall include areas to list and verify equipment as well as a minimum of initial and finals readings of values.
   4. Forms shall be submitted for all scheduled systems / equipment in the commissioning scope or as indicated by the CxA.

1.5 SUBMITTALS TO BE SUBMITTED BY CONTRACTOR – DURING THE CONSTRUCTION PHASE.

A. Construction schedule.
   1. Schedule of commissioning activities, integrated with the Construction Schedule. Time allotted for commissioning shall be coordinated with the CxA for specific equipment and systems. Commissioning shall be included in the schedule before the final completion date
   2. Contractor shall provide two-week look-ahead schedules to keep the CxA updated as schedules adjust during construction.
   3. A updated schedule shall be provided every two weeks.

B. Issues Log
   1. CxC shall provide an update on the resolution of each item every 2 weeks. The CxC shall verify, sign and date items as they are resolved.
   2. The Issues Log is created and populated by the CxA.
   3. The CxA shall verify items are resolved after the CxC has verified and signed off on the resolutions.

C. Equipment start up reports
   1. Reports with all information fully filled out on blank reports approved by the CxA and verified by the CxC shall be submitted for review by the CxA.
   2. Reports to be approved by the CxA before any equipment and systems are tested and balanced.

1.6 CLOSEOUT SUBMITTALS TO BE SUBMITTED BY CONTRACTOR – AT THE END OF THE CONSTRUCTION PHASE.

A. Operation and Maintenance (O&M) Data:
   1. For all equipment included in the design documents including but not limited to HVAC equipment, controls, lighting, etc. that was in the scope of the commissioning process the following shall be provided:
      a. Information on regular maintenance recommendations and requirements with suggested intervals
      b. Parts lists
      c. Trouble shooting guidelines
      d. Error code tables and possible causes (if applicable)
   2. O&M data to be submitted in PDF format with a table of contents and individual files named for the respective equipment tag.

1.7 COMPENSATION

A. If Architect/ Engineer, CxA, other Owner's witness, or Owner's staff perform additional services or incur additional expenses due to actions of Contractor listed below, the contractor shall compensate Owner / CxA for additional expenses.
   1. Failure to provide timely notice of commissioning activities schedule changes.
   2. Failure to fully correct items identified by the CxA as not passing the required tests and inspections by the first re-inspection.

   Contractor shall compensate the Architect/ Engineer, Owner and/or CxA for such additional services and expenses at the current hourly rates per labor hour.

PART 2 - PRODUCTS

A. Test equipment and instrumentation required to perform the commissioning process shall be provided by the contractor and remain the property of Contractor unless otherwise indicated.

B. Test equipment and instrumentation required to perform commissioning process shall comply with the following criteria:
   1. Be manufactured for the purpose of testing and measuring tests for which they are being used and have an accuracy to test and measure system performance within the tolerances required to determine acceptable performance.
   2. Calibrated and certified.
      a. Calibration performed and documented by a qualified calibration agency according to national standards applicable to the tools and instrumentation being calibrated. Calibration shall be current according to national standards or within test equipment and instrumentation manufacturer's recommended intervals, whichever is more frequent, but not less than within six months of initial use on Project. Calibration tags shall be permanently affixed.
      b. Repair and recalibrate test equipment and instrumentation if dismantled, dropped, or damaged since last calibrated.
   3. Maintain test equipment and instrumentation.
   4. Use test equipment and instrumentation only for testing or monitoring Work for which they are designed.

2.2 PROPRIETARY TEST EQUIPMENT, INSTRUMENTATION, AND TOOLS

A. Proprietary test equipment, instrumentation, and tools are those manufactured or prescribed by tested equipment manufacturer and required for work on its equipment as a condition of equipment warranty, or as otherwise required to service, repair, adjust, calibrate, or perform work on its equipment.
   1. Identify proprietary test equipment, instrumentation, and tools required in the test equipment identification list submittal.
   2. Proprietary test equipment, instrumentation, and tools shall become the property of Owner at Substantial Completion.

PART 3 - EXECUTION

3.1 PREPARATION

A. Review all commissioning requirements and documentation required including preliminary construction checklists, testing procedures and closeout information.

B. Contractor shall review prior to bidding and include all required labor and materials to perform the requirements listed in the specification.

3.2 GENERAL EXECUTION REQUIREMENTS

A. Schedule and coordinate commissioning process with the Construction Schedule.

B. Perform activities identified in functional performance testing under the guidance and direction of the CxA with the CxA or representative present. It is the contractor's responsibility to perform

all of the required testing and providing all necessary testing equipment to meet the requirements of the commissioning requirements.

C. Unless otherwise indicated, demonstrate tests for 100 percent of work to which the test applies.

D. Report test data and commissioning issue resolutions.

E. Schedule personnel to participate in and perform Commissioning-Process Work.

F. Installing contractors' commissioning responsibilities include, but are not limited to, the following:
   1. Operating the equipment and systems they install during tests.
   2. In addition, installing contractors may be required to assist in tests of equipment and systems with which their work interfaces if the Commissioning Coordinator requires.

3.3 COMMISSIONING COORDINATOR (CxC) RESPONSIBILITIES

A. Management and Coordination: Manage, schedule, and coordinate commissioning process, including, but not limited to, the following:
   1. Coordinate with subcontractors on their commissioning responsibilities and activities.
   2. Obtain, assemble, and submit commissioning documentation.
   3. Attend periodic on-site commissioning meetings.
   4. Develop and maintain the commissioning schedule. Integrate commissioning schedule into the Construction Schedule. Update Construction Schedule at specified intervals.
   5. Review and comment on preliminary test procedures and data forms.
   6. Report inconsistencies and issues in system operations.
   7. Verify that tests have been completed and results comply with acceptance criteria, and that equipment and systems are ready before scheduling test demonstrations.
   8. Direct and coordinate test demonstrations.
   9. Coordinate witnessing of test demonstrations by CxA / Owner's witness.
   10. Track commissioning issues until resolution and retesting is successfully completed.
   11. Retain original records of Commissioning-Process Work, organized as required for the commissioning report. Provide Owner's representative access to these records on request.

3.4 START UP REPORTS

A. Blank start up reports for all scheduled equipment shall be provided by the contractor for review by the CxA at the beginning of the project.

B. Startup: Perform and document initial operation of equipment to prove that it is installed properly and operates as intended according to manufacturer's standard startup procedures, at minimum.

C. Start up reports shall include the manufacturer’s recommended criteria and items as well as any additional information recommended by the contractor and required by the CxA. Performance Tests shall include:
   1. Static Tests: As specified elsewhere, including, but not limited to, duct and pipe leakage tests, insulation-resistance tests, and water-penetration tests.
   2. Component Performance Tests: Tests evaluate the performance of an input or output of components under a full range of operating conditions.
   3. Equipment and Assembly Performance Tests: Test and evaluate performance of equipment and assemblies under a full range of operating conditions and loads.

4. System Performance Tests: Test and evaluate performance of systems under a full range of operating conditions and loads.
5. Intersystem Performance Tests: Test and evaluate the interface of different systems under a full range of operating conditions and loads.

3.5 TEST AND BALANCE REPORTS

A. Systems and equipment shall be tested and balanced after the equipment startup has been performed and approved.

B. Test and balance procedures shall follow the requirements of the design documents.

C. Results of the testing and balancing shall be submitted for review with all issues subsequently resolved as noted and a revised report shall be submitted.

3.6 COMMISSIONING TESTING

A. Review and correct any and all issues from the construction check lists, start up reports and test & balance reports. Issues to be reviewed to be resolved and corrected.

Functional equipment and system testing to be performed by the contractor under the direction and guidance of the CxA. Contractor to perform all work and record data. Forms are based on approved equipment shop drawings, product data as well as the design documents.

B. The CxA shall provide the testing procedures and forms to be utilized during testing.
1. Test procedures shall define the step-by-step procedures to be used to execute tests and test demonstrations.
2. Test procedures shall be specific to the make, model, and application of the equipment and systems being tested.
3. Completed test data forms are the official records of the test results.

C. Review preliminary test procedures and test data forms, and provide comments within 14 days of receipt from Commissioning Authority. Review shall address the following:
   a. Equipment protection and warranty issues, including, but not limited to, manufacturers' installation and startup recommendations, and operation and maintenance instructions.
   b. Applicability of the procedure to the specific software, equipment, and systems approved for installation.

D. After Contractor has reviewed and commented on the preliminary test procedures and test data forms, Commissioning Authority will revise and reissue the approved revised test procedures and test data forms marked "Approved for Testing."

E. Use only approved test procedures and test data forms marked "Approved for Testing" to perform and document tests and test demonstrations.

F. Performance of Tests:
1. The sampling rate for tests is 100 percent. The sampling rate for test demonstrations is 100 percent unless otherwise indicated.
2. Perform and complete each step of the approved test procedures in the order listed.
3. Record data observed during performance of tests on approved data forms at the time of test performance and when the results are observed.

4. Record test results that are not within the range of acceptable results on commissioning issue report forms in addition to recording the results on approved test procedures and data forms according to the "Commissioning Compliance Issues" Paragraph in this Article.
5. On completion of a test, sign the completed test procedure and data form. Tests for which test procedures and data forms are incomplete, not signed, or which indicate performance that does not comply with acceptance criteria will be rejected. Tests for which test procedures and data forms are rejected shall be repeated and results resubmitted.

G. Performance of Test Demonstration:
1. Perform test demonstrations on a sample of tests after test data submittals are approved. The sampling rate for test demonstrations shall be 100 percent unless otherwise indicated in the individual test specification.
2. Perform and complete each step of the approved test procedures in the order listed.
3. Record data observed during performance of test demonstrations on approved data forms at the time of demonstration and when the results are observed.
4. False load test requirements are specified in related sections.
   a. Where false load testing is specified, provide temporary equipment, power, controls, wiring, piping, valves, and other necessary equipment and connections required to apply the specified load to the system. False load system shall be capable of steady-state operation and modulation at the level of load specified. Equipment and systems permanently installed in this work shall not be used to create the false load without Architect's written approval.

H. Commissioning Compliance Issues:
1. Test results that are not within the range of acceptable results are commissioning compliance issues.
2. Track and report commissioning compliance issues until resolution and retesting are successfully completed.
3. If a test demonstration fails, determine the cause of failure. Direct timely resolution of issue and then repeat the demonstration. If a test demonstration must be repeated due to failure caused by Contractor work or materials, reimburse Owner for billed costs for the participation in the repeated demonstration.
4. Test Results: If a test demonstration fails to meet the acceptance criteria, perform the following:
   a. Complete a commissioning compliance issue report form promptly on discovery of test results that do not comply with acceptance criteria.
   b. Submit commissioning compliance issue report form within 24 hours of the test.
   c. Determine the cause of the failure.
   d. Establish responsibility for corrective action if the failure is due to conditions found to be Contractor's responsibility.
5. Commissioning Compliance Issue Report: Provide a commissioning compliance issue report for each issue. Do not report multiple issues on the same commissioning compliance issue report.
   a. Exception: If an entire class of devices is determined to exhibit the identical issue, they may be reported on a single commissioning compliance issue report. (For example, if all return-air damper actuators that are specified to fail to the open position are found to fail to the closed position, they may be reported on a single commissioning issue report. If a single commissioning issue report is used for multiple commissioning compliance issues, each device shall be identified in the report, and the total number of devices at issue shall be identified.
   b. Complete and submit Part 1 of the commissioning compliance issue report immediately when the condition is observed.
   c. Record the commissioning compliance issue report number and describe the deficient condition on the data form.

d. Resolve commissioning compliance issues promptly. Complete and submit Part 2 of the commissioning compliance issue report when issues are resolved.

6. Diagnose and correct failed test demonstrations as follows:
   a. Perform diagnostic tests and activities required to determine the fundamental cause of issues observed.
   b. Record each step of the diagnostic procedure prior to performing the procedure. Update written procedure as changes become necessary.
   c. Record the results of each step of the diagnostic procedure.
   d. Record the conclusion of the diagnostic procedure on the fundamental cause of the issue.
   e. Determine and record corrective measures.
   f. Include diagnosis of fundamental cause of issues in commissioning compliance issue report.
7. Retest:
   a. Schedule and repeat the complete test procedure for each test demonstration for which acceptable results are not achieved. Obtain signature of Owner's witness on retest data forms. Repeat test demonstration until acceptable results are achieved. Except for issues that are determined to result from design errors or omissions, or other conditions beyond Contractor's responsibility, compensate Owner for direct costs incurred as the result of repeated test demonstrations to achieve acceptable results.
   b. For each repeated test demonstration, submit a new test data form, marked "Retest."
8. Do not correct commissioning compliance issues during test demonstrations.
   a. Exceptions will be allowed if the cause of the issue is obvious and resolution can be completed in less than 15 minutes. If corrections are made under this exception, note the deficient conditions on the test data form and issue a commissioning compliance issue report. A new test data form, marked "Retest," shall be initiated after the resolution has been completed.

3.7 COMMISSIONING MEETINGS

A. CxA will schedule and conduct commissioning meetings. The commissioning coordinator for the contractor and all other parties deemed necessary by the construction coordinator shall attend the meetings.

3.8 SEQUENCING

A. Sequencing of Commissioning Verification Activities: For a particular material, item of equipment, assembly, or system, perform the following in the order listed unless otherwise indicated:
   1. Construction Checklists:
      a. Startup, as appropriate. Some startup may depend on component performance. Such startup may follow component performance tests on which the startup depends.
      b. Test & balancing
   2. Commissioning tests.

B. Before performing commissioning tests, verify that materials, equipment, assemblies, and systems are delivered, installed, started, and adjusted to perform according to construction checklists.

C. Verify readiness of materials, equipment, assemblies, and systems by performing tests prior to performing test demonstrations. Notify Architect if acceptable results cannot be achieved due to conditions beyond Contractor's control or responsibility.

D. Commence tests as soon as installation checks for materials, equipment, assemblies, or systems are satisfactorily completed. Tests of a particular system may proceed prior to completion of other systems, provided the incomplete work does not interfere with successful execution of test.

3.9 SCHEDULING

A. Commence commissioning process as early in the construction period as possible.

B. Commissioning Schedule: Integrate commissioning activities into Construction Schedule.
   1. Include detailed commissioning activities in monthly updated Construction Schedule and short-interval schedule submittals.
   2. Schedule the start date and duration for the following commissioning activities:
      a. Submittals.
      b. Preliminary operation and maintenance manual submittals.
      c. Installation checks.
      d. Startup, where required.
      e. Performance tests.
      f. Performance test demonstrations.
      g. Commissioning tests.
      h. Commissioning test demonstrations.
   3. Schedule shall include a line item for each installation check, startup, and test activity specific to the equipment or systems involved.
   4. Determine milestones and prerequisites for commissioning process. Show commissioning milestones, prerequisites, and dependencies in monthly updated critical-path-method construction schedule and short-interval schedule submittals.

C. Two-Week Look-Ahead Commissioning Schedule:
   1. Two weeks prior to the beginning of tests, submit a detailed two-week look-ahead schedule. Thereafter, submit updated two-week look-ahead schedules weekly for the duration of commissioning process.
   2. Two-week look-ahead schedules shall identify the date, time, beginning location, Contractor personnel required, and anticipated duration for each startup or test activity.
   3. Use two-week look-ahead schedules to notify and coordinate participation of Owner's witnesses.

D. CxA Coordination:
   1. Coordinate with the CxA.
   2. Notify Architect / Owner / CxA of commissioning schedule changes at least 7 work days in advance for activities requiring the participation of CxA / Owner's witness.

3.10 COMMISSIONING REPORTS

A. Test Reports:
   1. Test data reports include the following:
      a. "As-tested" system configuration. Complete record of conditions under which the test was performed, including, but not limited to, the status of equipment, systems, and assemblies; temporary adjustments and settings; and ambient conditions.

b. Data and observations, including, but not limited to, data trend logs, recorded during the tests.
c. Signatures of individuals performing and witnessing tests.
d. Data trend logs accumulated overnight from the previous day of testing.

2. Commissioning Compliance Issue Reports: Report as commissioning compliance issues results of tests and test demonstrations that do not comply with acceptance criteria. Report only one issue per commissioning compliance issue report. Use sequentially numbered facsimiles of commissioning compliance issue report form included in this Section, or other form approved by Owner. Distribute commissioning compliance issue reports to parties responsible for taking corrective action. Identify the following:
   a. Commissioning compliance issue report number. Assign unique, sequential numbers to individual commissioning compliance issue reports when they are created, to be used for tracking.
   b. Action distribution list.
   c. Report date.
   d. Test number and description.
   e. Equipment identification and location.
   f. Briefly describe observations about the performance associated with failure to achieve acceptable results. Identify the cause of failure if apparent.
   g. Diagnostic procedure or plan to determine the cause (include in initial submittal)
   h. Diagnosis of fundamental cause of issues as specified below (include in resubmittal).
   i. Fundamental cause of unacceptable performance as determined by diagnostic tests and activities.
   j. When issues have been resolved, update and resubmit the commissioning issue report forms by completing Part 2. Identify resolution taken and the dates and initials of the persons making the entries.
   k. Schedule for retesting.
3. Weekly progress reports include information for tests conducted since the preceding report and the following:
   a. Completed data forms.
   b. Equipment or system tested, including test number, system or equipment tag number and location, and notation about the apparent acceptability of results.
   c. Activities scheduled but not conducted per schedule.
   d. Commissioning compliance issue report log.
   e. Schedule changes for remaining Commissioning-Process Work, if any.
4. Data trend logs shall be initiated and running prior to the time scheduled for the test demonstration.
   a. Trend log data format shall be multiple data series graphs. Where multiple data series are trend logged concurrently, present the data on a common horizontal time axis. Individual data series may be presented on a segmented vertical axis to avoid interference of one data series with another, and to accommodate different axis scale values. Graphs shall be sufficiently clear to interpret data within the accuracy required by the acceptance criteria.
   b. Attach to the data form printed trend log data collected during the test or test demonstration.
   c. Record, print out, and attach to the data form operator activity during the time the trend log is running. During the time the trend log is running, operator intervention not directed by the test procedure invalidates the test results.
5. System Alarm Logs: Record and print out a log of alarms that occurred since the last log was printed. Evaluate alarms to determine if the previous day's work resulted in any conditions that are not considered "normal operation."
   a. Conditions that are not considered "normal operation" shall be reported on a commissioning issue report attached to the alarm log. Resolve as necessary. The intent of this requirement is to discover control system points or sequences left in manual or disabled conditions, equipment left disconnected, set points left with

abnormal values, or similar conditions that may have resulted from failure to fully restore systems to normal, automatic control after test completion.

GENERAL COMMISSIONING REQUIREMENTS - SUMMARY

CxA – Commissioning Authority = Advanced Engineering Systems (AES)
Commissioning Coordinator (CxC) = Contractor
Functional Performance Test = FPT

Beginning of the construction phase.

- CxC to submit
- Contractor commissioning team members for General Contractor and all subcontractors including experience.
- CxC person designated as the contractors point of contact including experience.
- List of tools to be used for FPTs with specific information including last calibration data.
- Initial construction schedule with Cx activities included in the schedule.

Construction phase.

1. Construction Schedule
    a. On going construction schedule updates every 2 weeks with Cx activities included in the schedule.
2. Issues Log
    a. On going status of all items recorded in the Issues Log.
    b. Issues Log to be created and kept up to date with all issues or items needing resolution and tracked to ensure a resolution.
    c. The CxA shall create the log and add items as required.
    d. The CxC shall provide an update on the resolution of each item every 2 weeks. The CxC shall verify, sign and date items as they are resolved.
3. Equipment start-up reports (equipment start up sheets):
    a. Blank reports to be created by CxC based on manufacturer recommendations for use by the CxC.
    b. The CxA shall review and approve the reports before any equipment is started.
    c. CxC shall provide signed and dated pre-start up reports verifying that all equipment was started correctly with performance data.
    d. After signed reports by the CxC are provided, the CxA shall review and approve the reports. The reports can be double checked and verified by the CxA at their discretion.
4. Test and balance reports (TAB reports):
    a. Blank reports to be created by TAB contractor for use by the TAB contractor and CxC.
    b. The CxA shall review and approve the forms before any equipment / systems are tested and balanced.
    c. CxC shall provide signed and dated forms verifying that all equipment / systems were balanced correctly with performance data.
    d. After signed reports by the TAB contractor and CxC are provided, the CxA shall review and approve the reports. The reports can be double checked and verified by the CxA at their discretion.
5. Functional Performance Tests (FPTs)
    a. Functional Performance test forms created by the CxA shall be provided to the CxC for review before any testing is started.
    b. After all pre-start up reports, start up reports and TAB reports are complete for a given system / equipment then the FPTs can be scheduled and performed.
    c. FPTs shall be carried out by the CxC / designated personnel while the CxA observes and records the results. All tools or equipment required to carry out the FPTs are the responsibility of the CxC.

Closeout phase

1. Operation and Maintenance data (O&Ms)

a. Documentation for the owners use during the life of the building to facilitate regular maintenance and trouble shooting shall be complied and uploaded by the CxC for review and approval by the CxA.
b. After review by the CxA, the CxC shall revise documentation based on the CxA comments and resubmit.

END OF SECTION 01 91 13

SECTION 23 05 00

COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. The work covered under this Section of the Specifications is intended to include the furnishing of all equipment, materials and labor or reasonably incidental to the complete operating installation of systems as shown on the plan and of related equipment all as indicated on the drawings, as hereinbefore specified under Division 23 and as hereinafter specified in this Section.

B. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Sleeves.
5. Escutcheons.
6. Grout.
7. HVAC demolition.
8. Equipment installation requirements common to equipment sections.
9. Concrete bases.
10. Supports and anchorages.

1.03 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.04 SUBMITTALS

A. Welding certificates.

1.05 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

PART 2 - PRODUCTS

2.01 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.02 JOINING MATERIALS

A. Refer to individual Division 23 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8, BCuP Series or BAg1, unless otherwise indicated.

F. Welding Filler Metals: Comply with AWS D10.12.

G. Solvent Cements for Joining Plastic Piping:

1. CPVC Piping: ASTM F 493.
2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

2.03 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

E. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

F. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

2.04 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

B. Sealing Elements: EPDM or NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

C. Pressure Plates: Carbon steel. Include two for each sealing element.

D. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.05 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with set screws.

E. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.

F. PVC Pipe: ASTM D 1785, Schedule 40.

G. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

2.06 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.

1. Finish: Polished chrome-plated and rough brass, verify with Architect.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.

1. Finish: Polished chrome-plated and rough brass, verify with Architect.

2.07 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.01 HVAC DEMOLITION

A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
5. Equipment to Be Removed: Disconnect and cap services and remove equipment.
6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.02 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors.

M. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

N. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

O. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

P. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

Q. Verify final equipment locations for roughing-in.

R. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.03 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402, for safe-handling practice of cleaners, primers, and solvent cements.
2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
3. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
4. PVC Nonpressure Piping: Join according to ASTM D 2855.

J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

K. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

L. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

M. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.04 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.05 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.06 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.

2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement.

3.07 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.08 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.09 GROUTING

A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 23 05 00

SECTION 23 05 29

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. The work covered under this Section of the Specifications is intended to include the furnishing of all equipment, materials and labor or reasonably incidental to the complete operating installation of systems as shown on the plan and of related equipment all as indicated on the drawings, as hereinbefore specified under Division 23 and as hereinafter specified in this Section.

B. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Thermal-hanger shield inserts.
4. Fastener systems.
5. Equipment supports.

1.03 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits.

1. Design supports for equipment and multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Delegated-Design Submittal: For pipe hangers indicated to comply with performance requirements and design criteria, including analysis data.

1.05 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.06 QUALITY ASSURANCE

A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.01 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel or stainless steel.

2.02 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.03 THERMAL-HANGER SHIELD INSERTS

A. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength and vapor barrier intact for piping with liquids below 40 degrees F. For piping with liquids above 40 degrees F, wood blocking with vapor barrier intact

B. Insulation-Insert Material for Hot Piping: Wood blocking with vapor barrier intact.

C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.04 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated or stainless-steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.05 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.06 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.01 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

D. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer.

Install fasteners according to powder-actuated tool manufacturer's operating manual.

2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

E. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

F. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

G. Install hangers and supports to allow controlled thermal movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

H. Install lateral bracing with pipe hangers and supports to prevent swaying.

I. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

J. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

K. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

L. Insulated Piping:

1. Attach clamps and spacers to piping.

    a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.02 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.03 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.04 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods flush with support.

C. Provide closed cell insulation on sharp edges of all supports within 7’-6” of finished floor.

3.05 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports and metal trapeze pipe hangers and attachments for general service applications.

F. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 .
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
5. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
6. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
7. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
8. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
9. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.

2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.

8. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
9. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
2. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
3. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.

P. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 23 05 29

SECTION 23 05 53

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. The work covered under this Section of the Specifications is intended to include the furnishing of all equipment, materials and labor or reasonably incidental to the complete operating installation of systems as shown on the plan and of related equipment all as indicated on the drawings, as hereinbefore specified under Division 23 and as hereinafter specified in this Section.

1.03 ACTION SUBMITTAL

A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.01 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: Brass, 0.032-inch Stainless steel, 0.025-inch Aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
4. Fasteners: Stainless-steel rivets or self-tapping screws.
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: Black.
3. Background Color: White.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Make, Model, Capacities & Characteristics (example: CFM, GPM, BTU/H…).

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.02 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Red.

C. Background Color: White.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.03 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1-1/2 inches high.

2.04 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware or semi ridged plastic.

B. Supply Air Duct:

1. Background Color: Green
2. Letter Color: White

C. Return and Fresh Air Duct:

1. Background Color: Blue
2. Letter Color: White

D. Exhaust and Relief Air Duct:

1. Background Color: Yellow
2. Letter Color: Black

E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

H. Fasteners: Stainless-steel rivets or self-tapping screws or self-adhesive.

I. Paint/ Stencil: Maintain same color, temperature and size requirements as printed labels. Painted labels to be applied with crisp clean lines.

J. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
2. Lettering Size: At least 1-1/2 inches high.

2.05 VALVE TAGS

A. General Requirements for Manufactured valve tags: 1-1/2” diameter brass disc with stamped black filled character whose size are between ¼”-1/2”. Tags shall be painted to match the pipe label color and be connected to the valve with 12” long copper chains. Tag shall include a unique valve number. Do not use pipe tags for bare pipes conveying fluids at temperatures of 125 deg F or higher.

PART 3 - EXECUTION

3.01 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.02 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.03 PIPE LABEL INSTALLATION

A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 20 feet along each run. Reduce intervals to 10 feet in areas of congested piping and equipment.
7. Install labels longitudinally along top of painted or publically exposed ducts.

B. Pipe Label Color Schedule:

1. Coordinate colors with Owner/Engineer prior to ordering. The following are shown as default colors only.

3.04 DUCT LABEL INSTALLATION

A. Install plastic-laminated or self-adhesive duct labels with permanent adhesive on air ducts in the following color codes, coordinate color with Owner/Engineer prior to ordering:

1. Blue: For outside air supply ducts. (Cold air supply ducts in dual duct systems)
2. Yellow: For Exhaust ducts. (hot air supply ducts in dual duct systems)
3. Green: For supply air ducts.
4. Blue: For relief-, return-, and mixed-air ducts.
5. ASME A13.1 Colors and Designs: For hazardous material exhaust.

B. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 15 feet in each space where ducts are exposed or concealed by removable ceiling system.

C. Install labels longitudinally along top of painted or publically exposed ducts.

3.05 VALVE TAG INSTALLATION

A. Provide valves tags at all valves in all piping excluding fixture stops. Do not put valve tags on valves that are isolation valves within 5’ of equipment they serve and the function is obvious. A complete log of the tags, valve location, what the valve is serving shall be provided. An acceptable alternate is to label the valve on the tag with what the valve serves.

END OF SECTION 23 05 53

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. The work covered under this Section of the Specifications is intended to include the furnishing of all equipment, materials and labor or reasonably incidental to the complete operating installation of systems as shown on the plan and of related equipment all as indicated on the drawings, as hereinbefore specified under Division 22 and as hereinafter specified in this Section.

B. Section Includes:

1. Balancing Air Systems:

a. Constant-volume air systems.
b. Variable-air-volume systems.

2. Balancing Hydronic Piping Systems:

a. Constant-flow hydronic systems.
b. Variable-flow hydronic systems.

1.03 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An entity engaged to perform TAB Work.

1.04 APPROVED CONTRACTORS

A. Air and Fluid Management, 217 S Wilson St, Wilber, NE 68465

B. Balcon Air and Water Balancing, 7905 L St, Omaha, NE 68358

C. Systems Management and Balancing, 925 SE Olson DR, Waukee, IA 50263.

D. MMC Testing and Balancing, 9751 S 142nd Street, Omaha, NE 68138

1.05 ACTION SUBMITTALS

1.06 INFORMATIONAL SUBMITTALS

A. Strategies and Procedures Plan: Within 60 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

B. Certified TAB reports.

1.07 QUALITY ASSURANCE

A. TAB Contractor (Supervisor and Technician) Qualifications: Engage a TAB entity certified by AABC, NEBB or TABB.

B. Certify TAB field data reports and perform the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

C. TAB Report Forms: Use standard TAB contractor's forms.

D. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

E. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

F. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in

Section 233113 "Metal Ducts" and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine operating safety interlocks and controls on HVAC equipment.

L. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.02 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system-readiness checks and prepare reports. Verify the following:

1. Permanent electrical-power wiring is complete.
2. Automatic temperature-control systems are operational.
3. Equipment and duct access doors are securely closed.
4. Balance, smoke, and fire dampers are open.
5. Isolating and balancing valves are open and control valves are operational.
6. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
7. Windows and doors can be closed so indicated conditions for system operations can be met.

3.03 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" or ASHRAE 111] NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" or SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.

1. Comply with requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," Section 230719 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

E. Units shall be balanced and tested in all operation modes including but not limited to heating, cooling and dehumidification. Operate units on all stages.

F. All spaces with critical differential pressure requirements being positive or negative to adjoining spaces or the exterior shall be measured initially and at design air flows. If pressure readings are not as they should be, then the engineer shall be consulted on resolving the situation to achieve the proper pressure relationship. All measurements shall be documented in the final report.

G. Overall building pressure shall be measured at all exterior doors initially and at design air flows. If pressure readings are not as they should be, then the engineer shall be consulted on resolving the situation to achieve the proper pressure relationship. All measurements shall be documented in the final report.

3.04 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

M. All spaces with critical differential pressure requirements being positive or negative to adjoining spaces or the exterior shall be measured initially and at design air flows. If pressure readings are not as they should be, then the engineer shall be consulted on resolving the situation to achieve the proper pressure relationship. All measurements shall be documented in the final report.

N. Overall building pressure shall be measured at all exterior doors initially and at design air flows. If pressure readings are not as they should be, then the engineer shall be consulted on resolving the situation to achieve the proper pressure relationship. All measurements shall be documented in the final report.

3.05 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

    a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.

2. Measure fan static pressures as follows to determine actual static pressure:

    a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
    b. Measure static pressure directly at the fan outlet or through the flexible connection.
    c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
    d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.

    a. Report the cleanliness status of filters and the time static pressures are measured.

4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
5. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and

measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure airflow of submain and branch ducts.

a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure air outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.06 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
3. Measure total system airflow. Adjust to within indicated airflow.
4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air

outlets downstream from terminal units the same as described for constant-volume air systems.

5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

    a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
8. Record final fan-performance data.

C. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Balance variable-air-volume systems the same as described for constant-volume air systems.
2. Set terminal units and supply fan at full-airflow condition.
3. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
4. Readjust fan airflow for final maximum readings.
5. Measure operating static pressure at the sensor that controls the supply fan if one is installed, and verify operation of the static-pressure controller.
6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.
7. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.

    a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.

8. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

    a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

D. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.
2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.
3. Set terminal units at full-airflow condition.
4. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit

to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.

5. Adjust terminal units for minimum airflow.
6. Measure static pressure at the sensor.
7. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

3.07 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data, and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.
2. Check liquid level in expansion tank.
3. Check makeup water-station pressure gage for adequate pressure for highest vent.
4. Check flow-control valves for specified sequence of operation, and set at indicated flow.
5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.08 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Measure water flow at pumps. Use the following procedures except for positive-displacement pumps:

1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.

    a. Monitor motor performance during procedures and do not operate motors in overload conditions.

3. Report flow rates that are not within plus or minus 10 percent of design.

B. Measure flow at all automatic flow control valves to verify that valves are functioning as designed. Take pressure differential readings across valve and verify valve gpm matches design.

C. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.

D. Set calibrated balancing valves, if installed, at calculated presettings.

E. Measure flow at all stations and adjust, where necessary, to obtain first balance.

1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

F. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

G. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:

1. Determine the balancing station with the highest percentage over indicated flow.
2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
3. Record settings and mark balancing devices.

H. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

I. Measure the differential-pressure-control-valve settings existing at the conclusion of balancing.

J. Check settings and operation of each safety valve. Record settings.

3.09 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.10 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove

proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.11 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.

1. Measure and record the operating speed, airflow, and static pressure of each fan.
2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
3. Check the condition of filters.
4. Check the condition of coils.
5. Check the operation of the drain pan and condensate-drain trap.
6. Check bearings and other lubricated parts for proper lubrication.
7. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:

1. New filters are installed.
2. Coils are clean and fins combed.
3. Drain pans are clean.
4. Fans are clean.
5. Bearings and other parts are properly lubricated.
6. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.

1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
3. If calculations increase or decrease the air flow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
4. Balance each air outlet.

3.12 TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 5 percent or minus 10 percent.
2. Air Outlets and Inlets: Plus 5 percent or minus 10 percent.
3. Heating-Water Flow Rate: Plus 5 percent or minus 10 percent.
4. Cooling-Water Flow Rate: Plus 5 percent or minus 10 percent.

3.13 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: Prepare biweekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.14 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and product data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB contractor.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Notes to explain why certain final data in the body of reports vary from indicated values.
13. Test conditions for fans and pump performance forms including the following:

a. Settings for outdoor-, return-, and exhaust-air dampers.
b. Conditions of filters.
c. Cooling coil, wet- and dry-bulb conditions.
d. Face and bypass damper settings at coils.
e. Fan drive settings including settings and percentage of maximum pitch diameter.
f. Inlet vane settings for variable-air-volume systems.
g. Settings for supply-air, static-pressure controller.
h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.
8. Critical Room and building differential pressure relationships

3.15 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 23 05 93

SECTION 23 08 00

COMMISSIONING OF HVAC

PART 1 - **GENERAL**

1.01 SUMMARY

A. The work covered under this Section of the Specifications is intended to include the furnishing of all equipment, materials and labor or reasonably incidental to the complete operating installation of systems as shown on the plan and of related equipment all as indicated on the drawings, as hereinbefore specified under Division 23 and as hereinafter specified in this Section. Equipment to include:
   1. Boiler
   2. Heat Exchangers
   3. HVAC pumps
   4. HVAC controls
   5. Associated HVAC control devices such as dampers and sensors.

B. Section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.

C. Related Sections:

   1. Section 019113 "General Commissioning Requirements" for general commissioning process requirements.

1.02 DEFINITIONS

A. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.

B. CxA: Commissioning Authority.

C. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.

D. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.03 SUBMITTALS

A. Review Section 019113 "General Commissioning Requirements" for general commissioning process requirements." and provide all documentation as required related to the scope of work in this division. Coordinate submittals with the general contractor and commissioning coordinator.

1.04 CONTRACTOR'S RESPONSIBILITIES

A. Coordinate with the CxA and commissioning coordinator for all phases of the commissioning process throughout the project.

B. Provide all required information to the commissioning coordinator for the required submittals and information throughout the project.

C. Perform all commissioning tests at the direction of the CxA. Provide all required tools and instruments as required by the commissioning testing.

D. Attend construction phase commissioning coordination meetings for general construction as well as discipline specific including controls and test & balance.

E. Participate in HVACR systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

F. Provide information requested by the CxA for final commissioning documentation.

G. Provide measuring instruments and logging devices to record test data and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.05 CxA'S RESPONSIBILITIES

A. Provide Project-specific commissioning process test procedures for actual HVACR systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.

B. Direct commissioning testing.

C. Verify testing, adjusting, and balancing of Work are complete.

D. Provide test data, inspection reports, and certificates in Systems Manual.

1.06 COMMISSIONING DOCUMENTATION

A. Provide the following information to the CxA for inclusion in the commissioning plan:
   1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
   2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
   3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVACR systems, assemblies, equipment, and components to be verified and tested.
   4. Certificate of readiness, signed by the Contractor, certifying that HVACR systems, assemblies, equipment, components, and associated controls are ready for testing.
   5. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.
   6. Startup test reports

7. Test and inspection reports and certificates.
8. Corrective action documents.
9. Verification of testing, adjusting, and balancing reports.

PART 2 - **PRODUCTS (Not Used)**

PART 3 - **EXECUTION**

3.01 TESTING PREPARATION

A. Certify that HVACR systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify that HVACR instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.02 TESTING AND BALANCING VERIFICATION

A. Prior to performance of testing and balancing Work, provide copies of reports, sample forms, checklists, and certificates to the CxA.

B. Notify the CxA at least 14 days in advance of testing and balancing Work and provide access for the CxA to witness testing and balancing Work.

C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVACR systems at the direction of the CxA.
   1. The CxA will notify testing and balancing Contractor 14 days in advance of the date of field verification. Notice will not include data points to be verified.
   2. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.

3. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.03 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of HVACR testing shall include entire HVACR installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the HVACR Contractor, testing and balancing Contractor, and HVACR Instrumentation and Control Contractor shall prepare detailed testing plans, procedures, and checklists for HVACR systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the HVACR system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.04 HVACR SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. HVACR Instrumentation and Control System Testing, as directed by the CxA, coordinate with control contractor.

END OF SECTION 23 08 00

SECTION 23 09 00

HVAC DIRECT DIGITAL CONTROLS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Furnish all labor, materials, equipment, and services for the installation of a complete Direct Digital Control System (DDC) as indicated, in accordance with provisions of the Contract Documents. The District shall contract independently for graphic programming and integration related to this project on the Tridium N4 Supervisor.

B. Although such work is not specifically indicated, provide all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, and complete installation.

1.02 RELATED SECTIONS

A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as part of the contract documents.

B. The Owner will contract directly with the Commissioning Authority (CxA) for this project. All Contractors shall cooperate with the CxA to complete all required commissioning.

1.03 DESCRIPTION

A. Provide a new control system for the entire HVAC system in the entire building. Existing control systems can be reused including:

1. VFDs,
2. JACE controllers,
3. Wiring and conduit
4. auxiliary control devices (i.e. Control valves, damper actuators, pressure switches, freeze stats, pressure transducers, current sensors, relays).

Provide new:

1. Unit controllers – unit controllers must be fully programmable with NO locked programs or points.
2. Temperature sensors (air and water),
3. Thermostats, humidistats, co2 sensors and space sensors.
4. Programming, alarm set up, trending

B. General:

1. Omaha Public Schools is using the Niagara N4 software as the “Front End” interface to all buildings. All EMS equipment installed shall be compatible with Niagara N4. **The contractor shall provide all Niagara N4 integration services for Niagara integration. Integration shall follow the OPS EMS standards.**
2. All control system equipment, including sensors, transmitters, control modules and communication link wiring between controllers required for the installation shall be provided by the Temperature Control Contractor.

3. Communication wiring shall be tested to demonstrated functional operation.
4. All wiring and control hardware to be installed by the Temperature Control Contractor.
5. Temperature Control Contractor to provide all labor incidental to the Building Automation System including engineering assistance, start-up, check-out and programming.
6. Control valves and dampers to be furnished by the temperature control contractor and installed by Mechanical or Sheet metal contractor.
7. The control system shall consist of a high-speed, peer-to-peer network of DDC controllers, a control system server, and a web-based operator interface.

C. System software shall be based on a server/thin client architecture, designed around the open standards of web technology. The control system server shall be accessed using a Web browser over the control system network, the owner's local area network, and (at the owner's discretion) over the Internet. The intent of the thin-client architecture is to provide operators complete access to the control system via a Web browser. No special software other than a web browser shall be required to access point displays, and trends, configure trends, configure points and controllers, or to download programming into the controllers.

D. System shall use the BACnet protocol for communication between control modules. I/O points, schedules, setpoints, trends and alarms specified in the Sequence of Operations for HVAC Controls shall be BACnet objects.

1.04 QUALITY ASSURANCE

A. The following are the approved vendors for this project:

1. Schneider (Control Services)
2. Honeywell (Engineered Controls)
3. Trane (Trane)
4. Distech (Cerris Systems)

B. Other manufacture’s equipment may be proposed but must comply with the following specifications. To obtain bid approval, a detailed technical proposal shall be required of bidders and shall be furnished along with the bid. The information required shall list of at least 3 similar digital transmission, computer oriented, integrated DDC installations which have been on-line for at least 5 years. The list shall include a synopsis of the type of control strategies being implemented, name of primary contact and phone number along with the local service capability. Technical cut sheets for all non-approved products being proposed shall also be provided. Cut sheets shall provide technical information and network requirements. Also provide cut sheets for any custom editing/programming software required for programming controllers.

C. The BAS shall be installed by competent mechanics and checked out by competent technicians regularly employed by the manufacturer or manufacturer representative of the equipment. All JACE programming shall be done with a Niagara N4 certified programmer also regularly employed by the manufacturer or manufacturer representative.

D. Single source responsibility of the Temperature Control Contractor shall include JACE Programming, Niagara N4 programming and Graphics, installations, calibration, and check out of systems.

E. The Temperature Control Contractor shall have an in-place, local support facility with technical staff, spare parts inventory, and all necessary test diagnostic equipment.

1.05 CODES AND STANDARDS

A. It is the responsibility of the Temperature Control Contractor to be familiar with all codes, rules, ordinances, and regulations of the Authority Having Jurisdiction and their interpretations which are in effect at the site of work.

B. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with the current editions in effect 30 days prior to the receipt of bids of the following codes:

1. Federal Communications Commission (FCC)
2. Electronics Industries Association (EIA)
3. American Society of Mechanical Engineers (ASME)
4. Institute of Electrical and Electronics Engineers (IEEE)
5. National Electrical Manufacturers Association (NEMA)
6. National Fire Protection Association (NFPA)
7. Underwriter's Laboratories (UL)
8. Occupational Safety and Health Administration (OSHA)
9. National Electric Code (NEC)
10. International Building Code (IBC)

    a. Section 719 Ducts and Air Transfer Openings
    b. Section 907 Fire Alarm and Detection Systems
    c. Chapter 28 Mechanical

11. International Mechanical Code (IMC)
12. American National Standards Institute (ANSI)
13. American Society of Heating, Refrigeration and Air Conditioning Engineers
14. ANSI/ASHRAE Standard 135, BACnet - A Data Communication Protocol for Building Automation and Control Systems

C. The Temperature Control Contractor shall be solely responsible for compliance with all health and safety regulations, performing the work in a safe and competent manner, and use industry accepted installation procedures required for the work as outlined in this document.

D. All systems equipment, components, accessories, and installation hardware shall be new and free from defects and shall be UL listed where applicable. All components shall be in current production and shall be a standard product of the system or device manufacturer. Refurbished or reconditioned components are unacceptable. Each component shall bear the make, model number, device tag number (if any), and the UL label as applicable. All System components of a given type shall be the product of the same manufacturer.

1.06 SUBMITTALS

A. Product Data and Shop Drawings: Meet requirements of Section 01 30 00 on Shop Drawings, Product Data, and Samples. In addition, the contractor shall provide an electronic copy of all shop drawings or other submittals on hardware, software, and equipment to be installed or provided. No work may begin on any segment of this project until submittals have been approved for conformity with design intent. Provide drawings as AutoCAD 2013 (or newer) compatible files on magnetic or optical disk (file format: .DWG, .DXF, or comparable) and three 11” x 17” prints of each drawing. When manufacturer’s cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other

means. Each submitted piece of literature and drawing shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work. Submittal approval does not relieve Contractor of responsibility to supply sufficient quantities to complete work. Submittals shall be provided within 3 weeks of contract award. Submittals shall include:

1. DDC System Hardware

    a. A complete bill of materials to be used indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.
    b. Manufacturer's description and technical data such as performance curves, product specifications, and installation and maintenance instructions for items listed below and for relevant items not listed below:

        1) Direct digital controllers (controller panels)
        2) Transducers and transmitters
        3) Sensors (including accuracy data)
        4) Actuators
        5) Valves
        6) Relays and switches
        7) Control panels
        8) Power supplies
        9) Batteries
        10) Operator interface equipment
        11) Wiring

    c. Wiring diagrams and layouts for each control panel. Show termination numbers.
    d. Schematic diagrams for all field sensors and controllers. Provide floor plans of all sensor locations and control hardware. Riser diagrams showing control network layout, communication protocol, and wire types.

2. Controlled Systems

    a. Riser diagrams showing control network layout, communication protocol, and wire types. System architecture drawing shall identify the exact order in which devices are to be wired for communication, including equipment with packaged controls.
    b. A schematic diagram of each controlled system. The schematics shall have all control points labeled with point names shown or listed. The schematics shall graphically show the location of all control elements in the system. Locations of controllers, JACE, pressure transmitters etc. shall be provided.
    c. A schematic wiring diagram of each controlled system. Label control elements and terminals. Where a control element is also shown on control system schematic, use the same name.
    d. An instrumentation list (Bill of Materials) for each controlled system. List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.
    e. A mounting, wiring, and routing plan-view drawing. The design shall take into account HVAC, electrical, and other systems' design and elevation requirements. The drawing shall show the specific location of all concrete pads and bases and any special wall bracing for panels to accommodate this work.

f. A complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system.
g. A point list for each control system. List I/O points and software points specified in the Sequence of Operation. Indicate alarmed and trended points.

3. Quantities of items submitted shall be reviewed but are the responsibility of the Contractor.
4. BACnet Protocol Implementation Conformance Statement (PICS) for each submitted type of controller and operator interface.

B. Project Record Documents. Upon completion of installation, submit three copies of record (as- built) documents of the documents shall be submitted for approval prior to final completion and shall include:

1. Project Record Drawings. As-built versions of submittal shop drawings provided as AutoCAD 2013 (or newer) compatible files on magnetic or optical media (file format: .DWG, .DXF, or comparable) and as 11" x 17" prints.
2. Operation and Maintenance (O&M) Manual.
3. As-built versions of submittal product data.
4. Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
5. Operator's manual with procedures for operating control systems: logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
6. Programming manual or set of manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
7. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
8. Documentation of programs created using custom programming language including setpoints, tuning parameters, and object database. Electronic copies of programs shall meet this requirement if control logic, setpoints, tuning parameters, and objects can be viewed using furnished programming tools.
9. Graphic files, programs, and database on magnetic or optical media.
10. List of recommended spare parts with part numbers and suppliers.
11. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
12. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation or web server software, and graphics software.
13. Floor plan drawings identifying communication cable pathways through the building, controller locations and concealed sensor locations. Additionally, sensors that are installed in concealed locations shall have a photograph included that shows the location.
14. Licenses, guarantees, and warranty documents for equipment and systems.
15. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

C. Training Materials: Provide course outline and materials for each class before first class. Training shall be furnished via instructor-led sessions, computer-based training, or web-based training.

1.07 WORK BY OTHERS

A. Automatic Control Valves: Furnished by the Controls Contractor, installed by Mechanical under the supervision of the Temperature Control Contractor. All reducers and fittings necessary to install smaller than pipe size valves shall be furnished and installed under applicable piping sections.

B. Automatic Control Dampers: Furnished by the Controls Contractor, installed by Mechanical under the supervision of the Temperature Control Contractor. All sheet metal and duct modifications required to support the installation shall be provided by the Mechanical Contractor.

C. Piping Penetration: Water pressure and differential taps, valve manifolds, flow switches, thermal wells; installed by Mechanical under the supervision of the Temperature Control Contractor.

D. Power Source Wiring; and all 120 volts A.C. power source wiring: Furnished and installed under Division 26: Electrical:

E. The District shall contract independently for graphic programming and integration related to this project on the Tridium N4 Supervisor.

1.08 WARRANTY

A. Warrant work as follows:

1. At completion of final test of installation and acceptance by the District, provide any service incidental to proper performance for a period of one year. Provide one year in warranty service with minimum of 2 maintenance/calibration inspections. Unlimited telephone technical support for OPS employees shall also be provided during the warranty period. Telephone support shall be available Monday through Friday, 8:00 AM to 5:00 PM.
2. Warrant labor and materials for specified control system free from defects for a period of 12 months after final acceptance. Control system failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within 24 hours of Owner’s warranty service request.
3. Exception: Contractor shall not be required to warrant reused devices except those that have been rebuilt or repaired. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of Engineer’s acceptance.

1.09 OWNERSHIP OF PROPRIETARY MATERIAL

A. Project-specific software and documentation shall become Owner's property. This includes, but is not limited to:

1. Graphics
2. Record drawings
3. Database
4. Application programming code

5. Documentation

PART 2 - PRODUCTS

2.01 GENERAL

A. The Direct Digital Control System shall consist of the following:

1. Standalone DDC panels (JACE).
2. Application specific controllers.
3. Local Display Devices.

B. JACE 8000 - The School District has standardized on Niagara N4 as the main system software and architecture. All JACES installed must have the same point capacity. Point capacity shall not exceed 250 points per JACE. When point count becomes 80% of the JACE capacity (200 Points) additional JACE's are required.

C. The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, standalone DDC panels, and operator devices.

D. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC shall operate independently by performing its own specified control, alarm management, operator I/O, and historical data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

E. Standalone DDC panels shall be able to access any data from or send control commands and alarm reports directly to any other DDC panel or combination of panels on the network without dependence upon a central processing device, such as a central file server. Standalone DDC panels shall also be able to send alarm reports to multiple operator workstations, terminals, and printers without dependence upon a central processing device or File Server.

2.02 MATERIALS

A. Use new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner. Spare parts shall be available for at least five years after completion of this contract.

2.03 NETWORKING/COMMUNICATION

A. Design of the DDC shall network operator workstations and Standalone DDC Panels as indicated on drawings. Inherent in the system's design shall be the ability to expand or modify the network via a local network.

1. Local Area Network:

a. Dynamic Data Access: All operator devices shall have the ability to access all point status and application report data or execute control functions for any and all other devices via the local area network.
b. Access to system data shall not be restricted by the hardware configuration of the DDC. Hardware configuration of the DDC network shall be transparent to user when accessing data or developing control programs.

c. General Network Design: Network design shall include the following provisions:

1) High speed data transfer rates for alarm reporting, quick report generation from multiple controllers, and upload/download efficiency between network devices.
2) Support of any combination of controllers directly connected to the local area network.
3) Detection and accommodation of single or multiple failures of either DDC panels or the network media. The network shall include provisions for automatically re-configuring itself to allow all operational equipment to perform their designated functions as effectively as possible in the event of single or multiple failures.
4) Message and alarm buffering to prevent information from being lost.
5) Error detection, correction, and re-transmission to guarantee data integrity.
6) Default device definition to prevent loss of alarms or data, and ensure alarms are reported as quickly as possible in the event an operator device does not respond.
7) Commonly available, multiple sourced, networking components shall be used to allow the DDC to coexist with other networking applications. The following are acceptable technologies: BACNET or ETHERNET.
8) Communications must be that of a deterministic nature to assure calculable performance under worst case network loading. When a collision-based network is proposed, Contractor shall provide detailed calculations indicating worse-case network response times.
9) Automatic synchronization of the real-time clocks in all DDC panels shall be provided.

B. System Software.

1. System Graphics. This contract requires the creation of all system graphics on the Building Control System Server .
2. Integration and central system graphics shall be provided by an independent third party on the District-Wide Niagara Tridium N4 Supervisor.
3. The operator interface on the Building Control System Server shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using dynamic colors to represent zone temperature relative to zone setpoint.

a. Functionality. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point-and-click navigation between zones or equipment, and to edit setpoints and other specified parameters.
b. Animation. Graphics shall be able to animate by displaying different image files for changed object status.
c. Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.
d. Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser

standards. Web graphic format shall require no plug-in (such as HTML and JavaScript) or shall only require widely available no-cost plug-ins (such as Active-X and Adobe Flash).

C. System Applications. System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs. If furnished as part of the interface, the tool shall be available from each workstation or web browser interface. If furnished as a stand-alone program, software shall be installable on standard IBM-compatible PCs with no limit on the number of copies that can be installed under the system license.

1. Automatic System Database Configuration. Each workstation or web server shall store on its hard disk a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.
2. Manual Controller Memory Download. Operators shall be able to download memory from the system database to each controller.
3. System Configuration. The workstation software shall provide a method of configuring the system. This shall allow for future system changes or additions by users under proper password protection. Operators shall be able to configure the system.
4. On-Line Help. Provide a context-sensitive, on-line help system to assist the operator in operating and editing the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext.
5. Security. Each operator shall be required to log on to the system with username and password in order to view, edit, add, or delete data. The Tridum N4 Supervisor and all connected DDC Control Systems shall utilize the District's Active Directory for Single Source Login.

    a. Operator Access. The username and password combination shall define accessible viewing, editing, adding, and deleting privileges for that operator. Users with system administrator rights shall be able to create new users and edit the privileges of all existing users.
    b. Automatic Log Out. Automatically log out each operator if no keyboard or mouse activity is detected. This auto logoff time shall be user adjustable.
    c. Encrypted Security Data. Store system security data including operator passwords in an encrypted format. System shall not display operator passwords.

6. System Diagnostics. The system shall automatically monitor the operation of all building management panels and controllers. The failure of any device shall be annunciated to the operator.
7. Alarm Processing. System input and status objects shall be configurable to alarm on departing from and on returning to normal state. Operator shall be able to enable or disable each alarm and to configure alarm limits, alarm limit differentials, alarm states, and alarm reactions for each system object. Configure and enable alarm points as specified in the Sequences of Operation. Alarms shall be BACnet alarm objects and shall use BACnet alarm services.
8. Alarm Messages. Alarm messages shall use the English language descriptor for the object in alarm in such a way that the operator will be able to recognize the source, location, and nature of the alarm without relying on acronyms.
9. Alarm Reactions. Operator shall be able to configure (by object) what, if any actions are to be taken during an alarm. As a minimum, the workstation or web server shall be able to log, print, start programs, display messages, send e-mail, send page, and audibly annunciate.

10. Alarm and Event log. Operators shall be able to view all system alarms and changes of state from any location in the system. Events shall be listed chronologically. An operator with the proper security level may acknowledge and delete alarms and archive closed alarms to the workstation or web server hard disk.
11. Trend Logs. The operator shall be able to configure trend sample or change of value (COV) interval, start time, and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs. Controller shall sample and store trend data and shall be able to archive data to the hard disk. Configure trends as specified in the Sequences of Operation. Trends shall be BACnet trend objects.
12. Object and Property Status and Control. Provide a method for the operator to view, and edit if applicable, the status of any object or property in the system. The status shall be available by menu, on graphics, or through custom programs.
13. Reports and Logs. Operator shall be able to select, to modify, to create, and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.
14. Standard Reports. Furnish the following standard system reports:

    a. Objects. System objects and current values filtered by object type, by status (in alarm, locked, normal), by equipment, by geographic location, or by combination of filter criteria.
    b. Alarm Summary. Current alarms and closed alarms. System shall retain closed alarms for an adjustable period.
    c. Logs. System shall log the following to a database or text file and shall retain data for an adjustable period:

        1) Alarm History.
        2) Trend Data. Operator shall be able to select trends to be logged.
        3) Operator Activity. At a minimum, system shall log operator log in and log out, control parameter changes, schedule changes, and alarm acknowledgment and deletion. System shall date and time stamp logged activity.

15. Energy Reports. System shall include an easily configured energy reporting tool that provides the capabilities described in this section.

    a. The energy reporting tool shall be accessible through the same user interface (operator workstation software) as is used to manage the BAS.
    b. The energy reporting tool shall be preconfigured by the Contractor to gather and store energy demand and consumption data from each energy source that provides metered data to the BAS. Analog meter data shall be stored at 5 minute intervals unless otherwise specified in the Sequence of Operation. Binary or multiple-state meter data shall be stored at change of value (CoV) rate unless otherwise specified in the Sequence of Operation. This data shall be maintained in an industry standard SQL database for a period of not less than five years.
    c. The energy reporting tool shall allow the operator to select an energy source and a time period of interest (day, week, month, year, or date range) and shall provide options to view the data in a table, line graph, bar graph, or pie chart. The tool shall also allow the operator to select two or more data sources and display a comparison of the energy used over this period in any of the listed graph formats, or to total the energy used by the selected sources and display that data in the supported formats.

d. The energy reporting tool shall allow the operator to select and energy source and two time periods of interest (day, week, month, year, or date range) and display a graph that compares the energy use over the two time periods in any of the graph formats listed in the previous paragraph. The tool shall also allow the operator to select multiple energy sources and display a graph that compares the total energy used by these sources over the two time periods.

e. The energy reporting tool shall allow the operator to easily generate the previously described graphs "on the fly," and shall provide an option to store the report format so the operator can select that format to regenerate the graph at a future date. The tool shall also allow the user to schedule these reports to run on a recurring basis using relative time periods, such as automatically generating a consumption report on the first Monday of each month showing consumption over the previous month. Automatically generated reports shall be archived on the server in a common industry format such as Adobe PDF or Microsoft Excel with copies e-mailed to a user editable list of recipients.

f. The energy reporting tool shall be capable of collecting and displaying data from the following types of meters:

1) Gas
2) Potable Water
3) Electricity

g. The user shall have the option of using Btu/hr (Btu) as the units for demand and consumption reports. Multiples of these units (MWH, kBtu, etc.) shall be used as appropriate. All selected sources shall be automatically converted to the selected units. The user shall similarly have the option of entering facility area and occupancy hours and creating reports that are normalized on an area basis, an annual use basis, or an occupied hour basis.

h. The user shall have the option of entering benchmark data for an individual facility or a group of facilities.

i. The user shall have the option of displaying any or all of the following data on any chart, line, or bar graph generated by the energy reporting tool:

1) Low/High/Average value of the metered value being displayed.
2) Heating and/or Cooling Degree Days for the time period(s) being displayed.

D. Workstation Application Editors. Each PC or browser workstation shall support editing of all system applications via password protected web access. The applications shall be downloaded and executed at one or more of the controller panels.

1. Controller. Provide a full-screen editor for each type of application that shall allow the operator to view and change the configuration, name, control parameters, and set points for all controllers.
2. Scheduling. An editor for the scheduling application shall be provided at each workstation. Provide a method of selecting the desired schedule and schedule type. Exception schedules and holidays shall be shown clearly on the calendar. The start and stop times for each object shall be adjustable from this interface. All schedules shall be BACnet schedule objects.
3. Custom Application Programming. Provide the tools to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded. Programming language shall have the following features:

a. Language. Language shall be graphically based or English language oriented. If graphically based, language shall use function blocks arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below, and operators shall be able to create custom or compound function blocks. Any ancillary software required to support function block programming shall be supplied with the control system. If English language oriented, language shall be based on the syntax of BASIC, FORTRAN, C, or PASCAL, and shall allow for free-form programming that is not column- oriented or "fill-in-the-blanks."

b. A full-screen character editor programming environment shall be provided. The editor shall be cursor/mouse-driven and allow the user to insert, add, modify, and delete custom programming code. It also shall incorporate features such as cut/ paste and find.

c. The programming language shall allow independently executing program modules to be developed. Each module shall be able to independently enable and disable other modules.

d. The editor/programming environment shall have a debugging/simulation capability that allows the user to step through the program and observe any intermediate values and/or results.

e. The programming language shall support conditional statements (IF/THEN/ELSE/ ELSE-IF) using compound Boolean (AND, OR, and NOT) and/or relations (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.

f. The programming language shall support floating-point arithmetic using the following operators: +, , ÷, ×, and square root. The following mathematical functions also shall be provided: absolute value and minimum/maximum value.

g. The programming language shall have predefined variables that represent time of day, day of the week, month of the year, and the date. Other predefined variables shall provide elapsed time in seconds, minutes, hours, and days. These elapsed time variables shall be able to be reset by the language so that interval-timing functions can be stopped and started within a program. Values from all of the above variables shall be readable by the language so that they can be used in a program for such purposes as IF/ THEN comparisons, calculations, etc.

h. The language shall be able to read the values of the variables and use them in programming statement logic, comparisons, and calculations.

i. The programming language shall have predefined variables representing the status and results of the system software and shall be able to enable, disable, and change the setpoints of the system software described below.

    1) Portable Operator's Provide one Microsoft Surface 7 Laptop with all controller service software installed. The controller software shall allow the technician to manually control all output points, read values of all input points and virtual points for all provided controllers. The Service software shall allow OPS to edit, develop new or delete any custom programming. Laptop shall be provided with all required cabling to interface to all provided field controllers including JACE.

2.04 CONTROLLER SOFTWARE

A. Furnish the following applications for building and energy management. All software application shall reside and operate in the system controllers. Applications shall be editable through operator workstation, web browser interface, or engineering workstation.

B. Provide one Microsoft Surface 7 Laptop with all controller service software installed. The controller software shall allow the technician to manually control all output points, read values of all input points and virtual points for all provided controllers. The Service software shall allow OPS to edit, develop new or delete any custom programming. Laptop shall be provided with all required cabling to interface to all provided field controllers.

C. System Security. See Paragraph 2.3.E.5 (Security) and Paragraph 2.3.E.14.c.iii (Operator Activity).

D. Scheduling. Provide the capability to execute control functions according to a user created or edited schedule. Each schedule shall provide the following schedule options as a minimum:

1. Weekly Schedule. Provide separate schedules for each day of the week. Each schedule shall be able to include up to 5 occupied periods (5 start-stop pairs or 10 events). Initial schedules shall provide for Optimal start of the equipment 2 hours before occupancy. Start time is 7:40 and stop time is 5:00.
2. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule has executed, the system shall discard and replace the exception schedule with the standard schedule for that day of the week.
3. Holiday Schedules. Provide the capability for the operator to define up to 24 special or holiday schedules. These schedules will be repeated each year. The operator shall be able to define the length of each holiday period.
4. All schedules shall be BACnet schedule objects.

E. System Coordination. Operator shall be able to group related equipment based on function and location and to use these groups for scheduling and other applications.

F. Binary Alarms. Each binary object shall have the capability to be configured to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.

G. Analog Alarms. Each analog object shall have both high and low alarm limits. The operator shall be able to enable or disable these alarms.

H. Alarm Reporting. The operator shall be able to determine the action to be taken in the event of an alarm. An alarm shall be able to start programs, print, be logged in the event log, generate custom messages, and display on graphics.

I. Remote Communication. System shall automatically contact operator workstation or server on receipt of critical alarms.

J. Demand Limiting.

1. The demand-limiting program shall monitor building power consumption from a building power meter (provided by others) which generates pulse signals or a BACnet communications interface. An acceptable alternative is for the system to

monitor a watt transducer or current transformer attached to the building feeder lines.

2. When power consumption exceeds adjustable levels, system shall automatically adjust setpoints, de-energize low-priority equipment, and take other programmatic actions to reduce demand as specified in the Sequence of Operation. When demand drops below adjustable levels, system shall restore loads as specified.

K. Maintenance Management. The system shall be capable of generating maintenance alarms when equipment exceeds adjustable runtime, equipment starts, or performance limits. Configure and enable maintenance alarms as specified in the Sequence of Operation.

L. Sequencing. Application software shall sequence chillers, boilers, and pumps as specified in Section the Sequence of Operation.

M. PID Control. System shall provide direct- and reverse-acting PID (proportional-integral-derivative) algorithms. Each algorithm shall have anti-windup and selectable controlled variable, setpoint, and PID gains. Each algorithm shall calculate a time-varying analog value that can be used to position an output or to stage a series of outputs. The calculation interval, PID gains, and other tuning parameters shall be adjustable by a user with the correct security level.

N. Staggered Start. System shall startup by time schedules and restart after power outage. All HVAC contained within an area or zone shall stagger the startup of the equipment. Operator shall be able to adjust equipment restart order and time delay between equipment restarts.

O. Energy Calculations.

1. The system shall accumulate and convert instantaneous power (kW) or flow rates (gpm) to energy usage data.
2. The system shall calculate a sliding-window average (rolling average). Operator shall be able to adjust window interval to 15 minutes, 30 minutes, or 60 minutes.

P. Anti-Short Cycling. All binary output objects shall be protected from short cycling by means of adjustable minimum on-time and off-time settings.

Q. On and Off Control with Differential. Provide an algorithm that allows a binary output to be cycled based on a controlled variable and a setpoint. The algorithm shall be direct-acting or reverse-acting.

R. Runtime Totalization. Provide software to totalize runtime for each binary input and output. Operator shall be able to enable runtime alarm based on exceeded adjustable runtime limit. Configure and enable runtime totalization and alarms as specified in the Sequence of Operation.

2.05 CONTROLLERS

A. General. Provide an adequate number of JACE Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), Smart Actuators (SA), and Smart Sensors (SS) as required to achieve performance specified. Every device in the system which executes control logic and directly controls HVAC equipment must conform to a standard BACnet Device profile as specified in ANSI/ASHRAE 135, BACnet Annex L. Unless otherwise specified, hardwired actuators and sensors may be

used in lieu of BACnet Smart Actuators and Smart Sensors. Building controllers shall be JACE8000.

B. BACnet.

1. Building Controllers (BCs). Each BC shall conform to BACnet Building Controller (B- BC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L, and shall be listed as a certified B-BC in the BACnet Testing Laboratories (BTL) Product Listing.
2. Advanced Application Controllers (AACs). Each AAC shall conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-AAC in the BACnet Testing Laboratories (BTL) Product Listing.
3. Application Specific Controllers (ASCs). Each ASC shall conform to BACnet Application Specific Controller (B-ASC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-ASC in the BACnet Testing Laboratories (BTL) Product Listing.
4. Smart Sensors (SSs). Each SS shall conform to BACnet Smart Sensor (B-SS) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-SS in the BACnet Testing Laboratories (BTL) Product Listing.
5. BACnet Communication.

    a. Each BC shall reside on or be connected to a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing.
    b. BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.
    c. Each AAC shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
    d. Each ASC shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
    e. Each SA shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
    f. Each SS shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using ARCNET or MS/TP Data Link/Physical layer protocol.

C. Communication

1. Service Port. Each controller shall provide a service communication port for connection to a Portable Operator’s Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.
2. Signal Management. BC and ASC operating systems shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.
3. Data Sharing. Each BC and AAC shall share data as required with each networked BC and AAC.
4. Stand-Alone Operation. Each piece of equipment specified shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or

other method for values normally read over the network such as outdoor air conditions, supply air or water temperature coming from source equipment, etc.

D. Environment. Controller hardware shall be suitable for anticipated ambient conditions.

1. Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -29°C to 60°C (-20°F to 140°F).
2. Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

E. Keypad. Provide a laptop and software and any interface cabling needed to use a laptop computer as a Portable Operator's Terminal for the system.

F. Real-Time Clock. Controllers that perform scheduling shall have a real-time clock.

G. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to a field-removable modular terminal strip or to a termination card connected by a ribbon cable. Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.

H. Memory.

1. Controller memory shall support operating system, database, and programming requirements.
2. Each BC and AAC shall retain BIOS and application programming for at least 72 hours in the event of power loss.
3. Each ASC and SA shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.

I. Immunity to Power and Noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m.

J. Transformer. ASC power supply shall be fused or current limiting and shall be rated at a minimum of 125% of ASC power consumption.

2.06 INPUT AND OUTPUT INTERFACE

A. General. Hard-wire input and output points to BCs, AACs, ASCs, or SAs.

B. Protection. All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground shall cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no controller damage.

C. Space Setpoints. Space setpoints will be controllable from the space thermostat or from the BAS system. Operator will have the ability to choose if the setpoint used comes from the thermostat or BAS. On new installation the default shall be -Thermostat adjustments disabled and BAS enabled. Setpoints, both BAS and Local shall be limited to the following:

1. Cooling High Limit = 78
2. Cooling low limit = 70
3. Heating High Limit = 75
4. Cooling low limit = 68

D. Binary Inputs. Binary inputs shall allow the monitoring of ON/OFF signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against contact bounce and noise. Binary inputs shall sense dry contact closure without application of power external to the controller.

E. Pulse Accumulation Inputs. Pulse accumulation inputs shall conform to binary input requirements and shall also accumulate up to 10 pulses per second.

F. Analog Inputs. Analog inputs shall monitor low-voltage (0–10 Vdc), current (4–20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.

G. Binary Outputs. Binary outputs shall provide for ON/OFF operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on Building Controllers shall have three-position (on-off-auto) override switches and status lights. Outputs shall be selectable for normally open or normally closed operation.

H. Analog Outputs. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0–10 Vdc or a 4–20 mA signal as required to properly control output devices. Each Building Controller analog output shall have a two-position (auto-manual) switch, a manually adjustable potentiometer, and status lights. Analog outputs shall not drift more than 0.4% of range annually.

I. Tri-State Outputs. Control three-point floating electronic actuators without feedback with tri-state outputs (two coordinated binary outputs). Tri-State outputs may be used to provide analog output control in zone control and terminal unit control applications such as VAV terminal units, duct-mounted heating coils, and zone dampers.

J. System Object Capacity. The system size shall be expandable to at least twice the number of input/ output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system

2.07 POWER SUPPLIES AND LINE FILTERING

A. Power Supplies. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.

1. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand 150% current overload for at least three seconds without trip-out or failure.

a. Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
b. Line voltage units shall be UL recognized and CSA listed.

B. Power Line Filtering.

1. Provide internal or external transient voltage and surge suppression for workstations and controllers. Surge protection shall have:

a. Dielectric strength of 1000 V minimum
b. Response time of 10 nanoseconds or less
c. Transverse mode noise attenuation of 65 dB or greater
d. Common mode noise attenuation of 150 dB or greater at 40–100 Hz

2.08 AUXILIARY CONTROL DEVICES

A. Motorized Control Dampers, unless otherwise specified elsewhere, shall be as follow:

1. Type. Control dampers shall be the parallel or opposed-blade type as specified below or as scheduled on drawings.

a. Outdoor and return air mixing dampers and face-and-bypass dampers shall be parallel-blade and shall direct airstreams toward each other.
b. Other modulating dampers shall be opposed-blade.
c. Two-position shutoff dampers shall be parallel- or opposed-blade with blade and side seals.

2. Frame. Damper frames shall be 2.38 mm (13 gauge) galvanized steel channel or 3.175 mm (⅛ in.) extruded aluminum with reinforced corner bracing.
3. Blades. Damper blades shall not exceed 20 cm (8 in.) in width or 125 cm (48 in.) in length. Blades shall be suitable for medium velocity (10 m/s [2000 fpm]) performance. Blades shall be not less than 1.5875 mm (16 gauge).
4. Shaft Bearings. Damper shaft bearings shall be as recommended by manufacturer for application, oil impregnated sintered bronze, or better.
5. Seals. Blade edges and frame top and bottom shall have replaceable seals of butyl rubber or neoprene. Side seals shall be spring-loaded stainless steel. Blade seals shall leak no more than 50 L/s·m2(10 cfm per ft2) at 1000 Pa (4 in. w.g.) differential pressure. Blades shall be airfoil type suitable for wide-open face velocity of 7.5 m/s (1500 fpm).
6. Sections. Individual damper sections shall not exceed 125 cm × 150 cm (48 in. × 60 in.). Each section shall have at least one damper actuator.
7. Modulating dampers shall provide a linear flow characteristic where possible.
8. Linkages. Dampers shall have exposed linkages.

B. Electric Damper and Valve Actuators.

1. Stall Protection. Mechanical or electronic stall protection shall prevent actuator damage throughout the actuator’s rotation.
2. Spring-return Mechanism. Actuators used for power-failure and safety applications shall have an internal mechanical spring-return mechanism or an uninterruptible power supply (UPS).
3. Signal and Range. Proportional actuators shall accept a 0–10 Vdc or a 0–20 mA control signal and shall have a 2–10 Vdc or 4–20 mA operating range.. Outdoor Dampers and Heating Valves values shall be 0% for open and 100% for closed.

Chilled water valves shall be 0% wide3 open and 100% closed. (floating tri-state actuators may not be used unless pre-approved by owner).

4. Wiring. 24 Vac and 24 Vdc actuators shall operate on Class 2 wiring.
5. Manual Positioning. Operators shall be able to manually position each actuator when the actuator is not powered. Non-spring-return actuators shall have an external manual gear release. Spring-return actuators with more than 7 N·m (60 in.-lb) torque capacity shall have a manual crank.
6. All Damper and Valve Actuators shall be by Belimo.

C. Control Valves.

1. Control valves shall be two-way or three-way type for two-position or modulating service as shown.
2. Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:

    a. Water Valves:

        1) Two-way: 150% of total system (pump) head.
        2) Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.

3. Water Valves.

    a. Body and trim style and materials shall be in accordance with manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service.
    b. Sizing Criteria:

        1) Two-position service: Line size.
        2) Two-way modulating service: Valve CV shall be calculated based on design parameters and resulting calculation provided with the valve submittal. Pressure drop across the control valve shall not exceed 3 PSI.
        3) Three-way modulating service: Valve CV shall be calculated based on design parameters and resulting calculation provided with the valve submittal. Pressure drop across the control valve shall not exceed 3 PSI
        4) Valves ½ in. through 2 in. shall be bronze body or cast brass ANSI Class 250, spring-loaded, PTFE packing, quick opening for two-position service. Two-way valves to have replaceable composition disc or stainless steel ball.
        5) Valves 2½ in. and larger shall be cast iron ANSI Class 125 with guided plug and PTFE packing.

    c. Water valves shall fail normally open or closed, as scheduled on plans, or as follows:

        1) Water zone valves—normally open preferred.
        2) Heating coils in air handlers—normally open.
        3) Chilled water control valves—normally closed.
        4) Other applications—as scheduled or as required by sequences of operation.

D. Binary Temperature Devices.

1. Low-Voltage Space Thermostats. Low-voltage space thermostats shall be 24 V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed setpoint adjustment, 13°C–30°C (55°F–85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
2. Line-Voltage Space Thermostats. Line-voltage space thermostats shall be bimetal-actuated, open-contact type or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listing for electrical rating, concealed setpoint adjustment, 13°C–30°C (55°F–85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
3. Low-Limit Thermostats. Low-limit airstream thermostats shall be UL listed, vapor pressure type. Element shall be at least 6 m (20 ft) long. Element shall sense temperature in each 30 cm (1 ft) section and shall respond to lowest sensed temperature. Provide a minimum of 1.5 m (5 ft) of element length per 1 m2 (10 ft2) of duct cross- section. Low-limit thermostat shall be manual reset only.

E. Temperature Sensors.

1. Type. Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor.
2. Duct Sensors. Duct sensors shall be single point or averaging as shown. Averaging sensors shall be a minimum of 1.5 m (5 ft) in length per 1 m2 (10 ft2) of duct cross-section.
3. Immersion Sensors. Provide immersion sensors with a separable stainless steel well. Well pressure rating shall be consistent with system pressure it will be immersed in. Well shall withstand pipe design flow velocities.
4. Space Sensors. Space sensors shall have an adjustable setpoint adjustment and include space temperature, space humidity and space CO2. The space adjustment shall be disabled and control of the setpoint through the BAS.
5. Differential Sensors. Provide matched sensors for differential temperature measurement.

F. Humidity Sensors.

1. Duct and room sensors shall have a sensing range of 20%–80%.
2. Duct sensors shall have a sampling chamber.
3. Outdoor air humidity sensors shall have a sensing range of 20%–95% RH and shall be suitable for ambient conditions of -40°C–75°C (-40°F–170°F).
4. Humidity sensors shall not drift more than 1% of full scale annually.

G. Flow Switches. Flow-proving switches shall be paddle (water service only) or differential pressure type (air or water service) as shown. Switches shall be UL listed, SPDT snap-acting, and pilot duty rated (125 VA minimum).

1. Paddle switches shall have adjustable sensitivity and NEMA 1 enclosure unless otherwise specified.
2. Differential pressure switches shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.

H. CO2 Sensors

1. CO2 Sensors shall use non-dispersive infrared (NDIR) and equipped with automatic background calibration.
2. The CO2 sensor Have a range of 200 ppm to 2000 ppm or greater.
3. CO2 sensors shall be certified by the manufacturer to be accurate within plus or minus 75 ppm at a 600 and 1000 ppm concentration. The sensors shall be

factory or field calibrated and certified by the manufacturer to require calibration no more frequently than once every 5 years.

4. CO2 sensors must be located in the room between 3 ft and 6 ft above the floor or at the anticipated height of the occupants' heads.

I. Relays.

1. Control Relays. Control relays shall be plug-in type, UL listed, and shall have dust cover and LED "energized" indicator. Contact rating, configuration, and coil voltage shall be suitable for application.
2. Time Delay Relays. Time delay relays shall be solid-state plug-in type, UL listed, and shall have adjustable time delay. Delay shall be adjustable ±100% from setpoint shown. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure for relays not installed in local control panel.

J. Override Timers.

1. Unless implemented in control software, override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration required by application. Provide 0–6 hour calibrated dial unless otherwise specified. Flush mount timer on local control panel face or where shown.

K. Current Transmitters.

1. AC current transmitters shall be self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4–20 mA two-wire output. Full-scale unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.
2. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized.
3. Unit shall be split-core type for clamp-on installation on existing wiring.

L. Current Transformers.

1. AC current transformers shall be UL/CSA recognized and shall be completely encased (except for terminals) in approved plastic material.
2. Transformers shall be available in various current ratios and shall be selected for ±1% accuracy at 5 A full-scale output.
3. Use fixed-core transformers for new wiring installation and split-core transformers for existing wiring installation.

M. Voltage Transmitters.

1. AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4–20 mA output with zero and span adjustment.
2. Adjustable full-scale unit ranges shall be 100–130 Vac, 200–250 Vac, 250–330 Vac, and 400–600 Vac. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.
3. Transmitters shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized at 600 Vac rating.

N. Voltage Transformers.

1. AC voltage transformers shall be UL/CSA recognized, 600 Vac rated, and shall have built-in fuse protection.
2. Transformers shall be suitable for ambient temperatures of 4°C–55°C (40°F–130°F) and shall provide ±0.5% accuracy at 24 Vac and 5 VA load.
3. Windings (except for terminals) shall be completely enclosed with metal or plastic.

O. Power Monitors.

1. Selectable rate pulse output for kWh reading, 4–20 mA output for kW reading, N.O. alarm contact, and ability to operate with 5.0 amp current inputs or 0–0.33 volt inputs.
2. 1.0% full-scale true RMS power accuracy, +0.5 Hz, voltage input range 120–600 V, and auto range select.
3. Under voltage/phase monitor circuitry.
4. NEMA 1 enclosure.
5. Current transformers having a 0.5% FS accuracy, 600 VAC isolation voltage with 0–0.33 V output. If 0–5 A current transformers are provided, a three-phase disconnect/shorting switch assembly is required.

P. Hydronic Flowmeters

1. Insertion-Type Turbine Meter

a. Dual counter-rotating axial turbine elements, each with its own rotational sensing system, and an averaging circuit to reduce measurement errors due to swirl and flow profile distortion. Single turbine for piping 2 inches and smaller. Flow sensing turbine rotors shall be non-metallic and not impaired by magnetic drag.
b. Insertion type complete with ‘hot-tap’ isolation valves to enable sensor removal without water supply system shutdown.
c. Sensing method shall be impedance sensing (nonmagnetic and non-photoelectric)
d. Volumetric accuracy

1) ± 0.5% of reading at calibrated velocity
2) ± 1% of reading from 3 to 30 ft/s (10:1 range)
3) ± 2% of reading from 0.4 to 20 ft/s (50:1 range)

e. Each sensor shall be individually calibrated and tagged accordingly against the manufacturer’s primary standards which must be accurate to within 0.1% of flow rate and traceable to the National Institute of Standards and Technology (NIST).
f. Maximum operating pressure of 400 psi and maximum operating temperature of 200°F continuous (220°F peak).
g. All wetted metal parts shall be constructed of 316 stainless steel.
h. Analog outputs shall consist of non-interactive zero and span adjustments, a DC linearly of 0.1% of span, voltage output of 0-10 Vdc, and current output of 4-20 mA.

2. Magnetic Flow-Tube Type Flowmeter

a. Sensor shall be a magnetic flowmeter, which utilizes Faraday’s Law to measure volumetric fluid flow through a pipe. The flowmeter shall consist of two elements, the sensor and the electronics. The sensor shall gener

ate a measuring signal proportional to the flow velocity in the pipe. The electronics shall convert this EMF into a standard current output.

b. Electronic replacement shall not affect meter accuracy (electronic units are not matched with specific sensors).

c. Four-wire, externally powered, magnetic type flow transmitter with adjustable span and zero, integrally mounted to flow tube. Output signal shall be a digital pulse proportional to the flow rate (to provide maximum accuracy and to handle abrupt changes in flow). Standard 4-20 mA or 0-10 Vdc outputs may be used provided accuracy is as specified.

d. Flow Tube:

1) ANSI class 150 psig steel
2) ANSI flanges
3) Protected with PTFE, PFA, or ETFE liner rated for 245°F minimum fluid temperature

e. Electrode and grounding material

1) 316L Stainless steel or Hastelloy C
2) Electrodes shall be fused to ceramic liner and not require o-rings.

f. Electrical Enclosure: NEMA 4, 7

g. Approvals:

1) UL or CSA
2) NSF Drinking Water approval for domestic water applications

h. Performance

1) Accuracy shall be ±0.5% of actual reading from 3 to 30 ft/s flow velocities, and 0.015 ft/s from 0.04 to 3 ft/s.
2) Stability: 0.1% of rate over six months.
3) Meter repeatability shall be ±0.1% of rate at velocities > 3 ft/s.

3. Magnetic Insertion-Type Flowmeter

a. Magnetic Faraday point velocity measuring device.

b. Insertion type complete with hot-tap isolation valves to enable sensor removal without water supply system shutdown.

c. 4-20 mA transmitter proportional to flow or velocity.

d. Accuracy: larger of 1% of reading and 0.2 ft/s.

e. Flow range: 0.2 to 20 ft/s, bidirectional.

f. Each sensor shall be individually calibrated and tagged accordingly against the manufacturer's primary standards which must be accurate to within 0.1% of flow rate and traceable to the National Institute of Standards and Technology (NIST).

4. Vortex Shedding Flowmeter

a. Output: 4-20 mA, 0-10 Vdc, 0-5 Vdc.

b. Maximum Fluid Temperature: 800ºF (427 °C).

c. Wetted Parts: Stainless Steel.

d. Housing: NEMA 4X.

e. Turndown: 25:1 minimum.

f. Accuracy: 0.5% of calibrated span for liquids, 1% of calibrated span for steam and gases.
g. Body: Wafer style or ANSI flanged to match piping specification.

5. Transit-Time Ultrasonic Flowmeter

a. Clamp-On transit-time ultrasonic flowmeter
b. Wide-Beam transducer technology
c. 4-20 mA transmitter proportional to flow or velocity.
d. Accuracy: 0.5% of reading in range 1 to 30 ft/s, 0.001 ft/s sensitivity.

Q. Thermal Energy Meters

1. Matched RTD, solid state, or thermistor temperature sensors with a differential temperature accuracy of ±0.15°F.
2. Flow meter: See "Hydronic Flowmeters" section.
3. Unit accuracy of ±1% factory calibrated, traceable to NIST with certification.
4. NEMA 1 enclosure.
5. Panel mounted display.
6. UL listed.
7. Isolated 4–20 ma signals for energy rate and supply and return temperatures and flow.

R. Current Switches.

1. Current-operated switches shall be self-powered, solid-state with adjustable trip current. Select switches to match application current and DDC system output requirements.

S. Pressure Transducers.

1. Transducers shall have linear output signal and field-adjustable zero and span.
2. Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure 50% greater than calibrated span without damage.
3. Water pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Transducer shall have 4–20 mA output, suitable mounting provisions, and block and bleed valves.
4. Water differential pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Over-range limit (differential pressure) and maximum static pressure shall be 2000 kPa (300 psi.)Transducer shall have 4–20 mA output, suitable mounting provisions, and 5-valve manifold.

T. Differential Pressure Switches. Differential pressure switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum) and shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified. Differential pressure switches designated for High Limit functions shall be provided with Manual Reset if specified.

U. Pressure-Electric (PE) Switches.

1. Shall be metal or neoprene diaphragm actuated, operating pressure rated for 0–175 kPa (0–25 psig), with calibrated scale minimum setpoint range of 14–125 kPa (2–18 psig) minimum, UL listed.

2. Provide one- or two-stage switch action (SPDT, DPST, or DPDT) as required by application Electrically rated for pilot duty service (125 VA minimum) and/or for motor control.
3. Switches shall be open type (panel-mounted) or enclosed type for remote installation. Enclosed type shall be NEMA 1 unless otherwise specified.
4. Each pneumatic signal line to PE switches shall have permanent indicating gauge.

V. Occupancy Sensors. Occupancy sensors shall utilize Passive Infrared (PIR) and/or Microphonic Passive technology to detect the presence of people within a room. Sensors shall be mounted as indicated on the approved drawings. The sensor output shall be accessible by any lighting and/or HVAC controller in the system. Occupancy sensors shall be capable of being powered from the lighting or HVAC control panel, as shown on the drawings. Occupancy sensor delay shall be software adjustable through the user interface and shall not require manual adjustment at the sensor.

W. Local Control Panels.

1. All indoor control cabinets shall be fully enclosed NEMA 1 construction with (hinged door) key-lock latch and removable subpanels. A single key shall be common to all field panels and subpanels.
2. Interconnections between internal and face-mounted devices shall be prewired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600 volt service, individually identified per control/ interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.
3. Provide ON/OFF power switch with overcurrent protection for control power sources to each local panel.

2.09 WIRING AND RACEWAYS

A. General. Provide copper wiring, plenum cable, and raceways as specified in applicable sections of Division 26.

B. Insulated wire shall use copper conductors and shall be UL listed for 90°C (200°F) minimum service.

PART 3 - EXECUTION

3.01 EXAMINATION

A. The contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the engineer for resolution before rough-in work is started.

B. The contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate—or if any discrepancies occur between the plans and the contractor's work and the plans and the work of others—the contractor shall report these discrepancies to the engineer and shall obtain written instructions for any changes necessary to accommodate the contractor's work with the work of others. Any changes in the work covered by this specification made necessary by the failure or neglect of the contractor to report such discrepancies shall be made by—and at the expense of—this contractor.

3.02 PROTECTION

A. The contractor shall protect all work and material from damage by his/her work or employees and shall be liable for all damage thus caused.

B. The contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. The contractor shall protect any material that is not immediately installed. The contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.03 COORDINATION

A. Site

1. Where the mechanical work will be installed in close proximity to, or will interfere with, work of other trades, the contractor shall assist in working out space conditions to make a satisfactory adjustment. If the contractor installs his/her work before coordinating with other trades, so as to cause any interference with work of other trades, the contractor shall make the necessary changes in his/her work to correct the condition without extra charge.
2. Coordinate and schedule work with other work in the same area and with work dependent upon other work to facilitate mutual progress.

B. Submittals. See Specifications for submittal requirements.

C. Test and Balance.

1. The contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.
2. The contractor shall provide training in the use of these tools. This training will be planned for a minimum of 4 hours.
3. In addition, the contractor shall provide a qualified technician to coordinate and assist in the test and balance process as needed.
4. The tools used during the test and balance process will be returned at the completion of the testing and balancing.

D. Life Safety.

1. Duct smoke detectors required for air handler shutdown are provided under Division 28. Interlock smoke detectors to air handlers for shutdown as specified in the Sequence of Operation.
2. Smoke dampers and actuators required for duct smoke isolation are provided under Division 23. Interlock smoke dampers to air handlers as specified in the Sequence of Operation.
3. Fire and smoke dampers and actuators required for fire-rated walls are provided under Division 23. Fire and smoke damper control is provided under Division 28.

E. Coordination with controls specified in other sections or divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the contractor as follows:

1. All communication media and equipment shall be provided as specified.

2. Each supplier of a controls product is responsible for the configuration, programming, start up, and testing of that product to meet the sequences of operation.
3. The contractor shall coordinate and resolve any incompatibility issues that arise between control products provided under this section and those provided under other sections or divisions of this specification.
4. The contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.
5. The contractor is responsible for the interface of control products provided by multiple suppliers regardless of where this interface is described within the contract documents.

3.04 GENERAL WORKMANSHIP

A. Install equipment, piping, and wiring/raceway parallel to building lines (i.e. horizontal, vertical, and parallel to walls) wherever possible.

B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

C. Install equipment in readily accessible locations as defined by Chapter 1 Article 100 Part A of the National Electrical Code (NEC).

D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.

E. All equipment, installation, and wiring shall comply with industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.05 FIELD QUALITY CONTROL

A. All work, materials, and equipment shall comply with rules and regulations of applicable local, state, and federal codes and ordinances.

B. Contractor shall continually monitor the field installation for code compliance and quality of workmanship.

C. Contractor shall have work inspection by local and/or state authorities having jurisdiction over the work.

3.06 EXISTING EQUIPMENT

A. Wiring. Interconnecting control wiring shall be removed and shall become the property of the contractor unless specifically noted or shown to be reused.

B. Local Control Panels. Remove and deliver existing control panels to Owner.

C. Repair. Unless otherwise directed, the contractor is not responsible for repair or replacement of existing energy equipment and systems, valves, dampers, or actuators. Should the contractor find existing equipment that requires maintenance, the engineer is to be notified immediately.

D. Indicator Gauges. Where these devices remain and are not removed, they must be made operational and recalibrated to ensure reasonable accuracy.

E. Room Thermostats. Remove and deliver existing room thermostats to Owner unless otherwise noted. Patch and finish holes and marks left by removal to match existing walls.

F. Electronic Sensors and Transmitters. Remove and deliver existing sensors and transmitters to Owner.

G. Controllers and Auxiliary Electronic Devices. Remove and deliver existing controllers and auxiliary electronic devices to Owner.

H. Damper Actuators, Linkages, and Appurtenances. Remove and deliver existing damper actuators, linkages and appurtenances to Owner.

I. Control Valves. Replace existing control valves with new. Deliver removed control valves to Owner.

J. Control Compressed Air Systems. Replace existing control compressed air systems with new unless otherwise noted. Deliver removed systems to Owner.

K. Existing System Operating Schedule. Existing mechanical system may be disabled during this work.

L. The scheduling of fans through existing or temporary time clocks or control system shall be maintained throughout the DDC system installation

M. Install control panels where shown.

N. Modify existing starter control circuits, if necessary, to provide hand-off-auto control of each controlled starter. If new starters or starter control packages are required, these shall be included as part of this contract.

O. Patch holes and finish to match existing walls.

3.07 WIRING

A. Contractor shall provide and install EMS LAN connections. MAC address of new equipment shall be provided to Omaha Public Schools so reservations can be made. If additional LAN connections are required, the contractor is responsible to install LAN wiring as needed.

B. Contractor shall provide and install Systimax Cat6A from the BAS System to the appropriate OPS network switch. This needs to be completed by a Systimax certified installer per OPS standards. Contractor shall test and verify the Systimax cable is terminated and communicating properly. After communication is verified contractor is to contact OPS Energy Manager, Tony Zimmerman at 531-299-0180 to verify the Jace is communicating and verify network connections.

C. All control and interlock wiring shall comply with national and local electrical codes, and Division 26 of this specification, Where the requirements of this section differ from Division 26, the requirements of this section shall take precedence.

D. All NEC Class 1 (line voltage) wiring shall be UL listed in approved raceway according to NEC and Division 26 requirements.

E. All low-voltage wiring shall meet NEC Class 2 requirements. Low-voltage power circuits shall be subfused when required to meet Class 2 current limit.

F. Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used provided that cables are UL listed for the intended application.

G. All wiring in mechanical, electrical, or service rooms – or where subject to mechanical damage – shall be installed in raceway.

H. Do not install Class 2 wiring in raceways containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers).

I. Do not install wiring in raceway containing tubing.

J. Where Class 2 wiring is run exposed, wiring is to be run parallel along a surface or perpendicular to it and supported per the requirements of the NEC.

K. Where plenum cables are used without raceway, they shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceiling suspension systems.

L. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block.

M. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

N. Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the contractor shall provide step-down transformers.

O. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.

P. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.

Q. Size of raceway and size and type of wire type shall be the responsibility of the contractor in keeping with the manufacturer's recommendations and NEC requirements, except as noted elsewhere.

R. Include one pull string in each raceway 1 in. or larger.

S. Use color-coded conductors throughout with conductors of different colors.

T. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.

U. Conceal all raceways except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum clearance of 6 in. from high-temperature equipment (e.g. steam pipes or flues).

V. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.

W. Adhere to this specification's Division 26 requirement where raceway crosses building expansion joints.

X. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of vertical raceways.

Y. The contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

Z. Flexible metal raceways and liquid-tight flexible metal raceways shall not exceed 3 ft. in length and shall be supported at each end. Flexible metal raceway less than ½ in. electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways shall be used.

AA. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes and ends not terminating in boxes shall have bushings installed.

3.08 COMMUNICATION WIRING

A. The contractor shall adhere to the items listed in the "Wiring" article in Part 3 of the specification.

B. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling

C. Do not install communication wiring in raceways and enclosures containing Class 1 or other Class 2 wiring.

D. Maximum pulling, tension, and bend radius for the cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.

E. Contractor shall verify the integrity of the entire network following cable installation. Use appropriate test measures for each particular cable.

F. When a cable enters or exits a building, a lightning arrestor must be installed between the lines and ground. The lighting arrestor shall be installed according to manufacturer's instructions.

G. All runs of communication wiring shall be un-spliced length when that length is commercially available.

H. All communication wiring shall be labeled to indicate origination and destination data.

I. All communication wiring pathways shall be documented on the Controls As-Built drawings.

J. Grounding of coaxial cable shall be in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

K. BACnet MS/TP communications wiring shall be installed in accordance with ASHRAE/ANSI Standard 135. This includes but is not limited to:

1. The network shall use shielded, twisted-pair cable with characteristic impedance between 100 and 120 ohms. Distributed capacitance between conductors shall be less than 30 pF per foot.
2. The maximum length of an MS/TP segment is 4000 ft. with AWG 18 cable. The use of greater distances and/or different wire gauges shall comply with the electrical specifications of EIA-485.
3. The maximum number of nodes per segment shall be 32, as specified in the EIA 485 standard. Additional nodes may be accommodated using repeaters.
4. An MS/TP EIA-485 network shall have no T connections.

3.09 INSTALLATION OF SENSORS

A. Install sensors in accordance with the manufacturer's recommendations.

B. Mount sensors rigidly and adequately for environment within which the sensor operates.

C. Room temperature sensors shall be installed on concealed junction boxes properly supported by wall framing.

D. All wires attached to sensors shall be sealed in their raceways or in the wall to stop air transmitted from other areas from affecting sensor readings.

E. Sensors used in mixing plenums and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.

F. Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 1 ft. of sensing element for each 1 ft2 of coil area.

G. Do not install temperature sensors within the vapor plume of a humidifier. If installing a sensor downstream of a humidifier, install it at least 10 ft. downstream.

H. All pipe-mounted temperature sensors shall be installed in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.

I. Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.

J. Differential Air Static Pressure.

1. Supply Duct Static Pressure. Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the height-pressure tap tubing of the corresponding building static pressure sensor (if applicable) or to the location of the duct high-pressure tap and leave open to the plenum.
2. Return Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Pipe the low-pressure port to a tee in the low-pressure tap tubing of the corresponding building static pressure sensor.
3. Building Static Pressure. Pipe the low-pressure port of the pressure sensor to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe the high-pressure port to a location behind a thermostat cover.

4. The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
5. All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without use of ladders or special equipment.
6. All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shut-off valves installed before the tee.

K. Smoke detectors, freezestats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

L. Install humidity sensors for duct mounted humidifiers at least 10 ft. downstream of the humidifier. Do not install filters between the humidifier and the sensor.

3.10 FLOW SWITCH INSTALLATION

A. Use correct paddle for pipe diameter.

B. Adjust flow switch according to manufacturer's instructions.

3.11 ACTUATORS

A. General. Mount and link control damper actuators according to manufacturer's instructions.

1. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.
2. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
3. Provide all mounting hardware and linkages for actuator installation.

B. Electric/Electronic

1. Dampers: Actuators shall be direct mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° travel available for tightening the damper seal. Actuators shall be mounted following manufacturer’s recommendations.
2. Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.

3.12 WARNING LABELS

A. Permanent warning labels shall be affixed to all equipment that can be automatically started by the control system.

1. Labels shall use white lettering (12-point type or larger) on a red background.
2. Warning labels shall read as follows.

C A U T I O N
This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to "Off" position before servicing.

B. Permanent warning labels shall be affixed to all motor starters and control panels that are connected to multiple power sources utilizing separate disconnects.

1. Labels shall use white lettering (12-point type or larger) on a red background.
2. Warning labels shall read as follows.

C A U T I O N

This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing.

3.13 IDENTIFICATION OF HARDWARE AND WIRING

A. All wiring and cabling, including that within factory-fabricated panels shall be labeled at each end within 2 in. of termination with control system address or termination number.

B. Permanently label or code each point of field terminal strips to show the instrument or item served.

C. Identify control panels with minimum ½ in. letters on laminated plastic nameplates.

D. Identify all other control components with permanent labels. All plug-in components shall be labeled such that label removal of the component does not remove the label.

E. Identify room sensors related to terminal boxes or valves with nameplates.

F. Manufacturers' nameplates and UL or CSA labels shall be visible and legible after equipment is installed.

G. Identifiers shall match record documents.

3.14 CONTROLLERS

A. Provide a separate controller for each AHU or other HVAC system. A DDC controller may control more than one system provided that all points associated with the system are assigned to the same DDC controller. Points used for control loop reset, such as outside air or space temperature, are exempt from this requirement.

B. Building Controllers and Custom Application Controllers shall be selected to provide the required I/O point capacity required to monitor all of the hardware points listed in the Sequence of Operation.

3.15 PROGRAMMING

A. Provide sufficient internal memory for the specified sequences of operation and trend logging.

B. Point Naming. Name points in accordance with the Project Haystack Open Source Data Modeling Standard. Contractor shall submit a complete Points List containing the

Description, Point Name (Acronym), Tag, Point Type, Unit of Measure and Trend Properties, for approval prior to the start of any programming.

C. Software Programming.

1. Provide programming for the system and adhere to the sequences of operation provided. All other system programming necessary for the operation of the system, but not specified in this document, also shall be provided by the contractor. Embed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation. Use the appropriate technique based on the following programming types:

a. Text-based:

1) Must provide actions for all possible situations.
2) Must be modular and structured.
3) Must be commented.

b. Graphic-based:

1) Must provide actions for all possible situations.
2) Must be documented.

c. Parameter-based:

1) Must provide actions for all possible situations.
2) Must be documented.

2. Provide one Microsoft Surface 7 Laptop with all controller service software installed. The controller software shall allow the technician to manually control all output points, read values of all input points and virtual points for all provided controllers. The Service software shall allow OPS to edit, develop new or delete any custom programming. Laptop shall be provided with all required cabling in order to interface to all provided field controllers.

3.16 CONTROL SYSTEM CHECKOUT AND TESTING

A. Startup Testing. All testing listed in this article shall be performed by the contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the owner's representative is notified that the system is ready for Commissioning.

1. The contractor shall furnish all labor and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this specification.
2. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
3. Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures according to manufacturers' recommendations.
4. Verify that all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.
5. Verify that all analog output devices (I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct.

The contractor shall check all control valves and automatic dampers to ensure proper action and closure. The contractor shall make any necessary adjustments to valve stem and damper blade travel.

6. Verify that the system operation adheres to the sequences of operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops.
7. Alarms and Interlocks:

    a. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
    b. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
    c. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

3.17 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Demonstration.

1. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed his/her own tests.
2. The tests described in this section are to be performed in addition to the tests that the contractor performs as a necessary part of the installation, start-up, and debugging process and as specified in the "Control System Checkout and Testing" article in Part 3 of this specification. The engineer will be present to observe and review these tests. The engineer shall be notified at least 10 days in advance of the start of the testing procedures.
3. The demonstration process shall follow that approved in Part 1, "Submittals." The approved checklists and forms shall be completed for all systems as part of the demonstration.
4. The contractor shall provide at least two persons equipped with two-way communication and shall demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the calibration, response, and action of every point and system. Any test equipment required to prove the proper operation shall be provided by and operated by the contractor.
5. As each control input and output is checked, a log shall be completed showing the date, technician’s initials, and any corrective action taken or needed.
6. Demonstrate compliance with Part 1, "System Performance."
7. Demonstrate compliance with sequences of operation through all modes of operation.
8. Demonstrate complete operation of operator interface.
9. Additionally, the following items shall be demonstrated:

    a. DDC loop response. The contractor shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop’s response to a change in set point, which represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that

yields unreasonably under-damped or over-damped control shall require further tuning by the Contractor.

b. Demand limiting. The contractor shall supply a trend data output showing the action of the demand limiting algorithm. The data shall document the action on a minute-by-minute basis over at least a 30-minute period. Included in the trend shall be building kW, demand limiting set point, and the status of sheddable equipment outputs.

c. Optimum start/stop. The contractor shall supply a trend data output showing the capability of the algorithm. The change-of-value or change-of-state trends shall include the output status of all optimally started equipment, as well as temperature sensor inputs of affected areas. Only optimum start is required.

d. Interface to the building fire alarm system.

e. Operational logs for each system that indicate all set points, operating points, valve positions, mode, and equipment status shall be submitted to the architect/engineer. These logs shall cover three 48-hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in both printed and disk formats.

10. Any tests that fail to demonstrate the operation of the system shall be repeated at a later date. The contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.

B. Acceptance.

1. All tests described in this specification shall have been performed to the satisfaction of both the engineer and owner, or owner's representative, prior to the acceptance of the control system as meeting the requirements of completion. Any tests that cannot be performed due to circumstances beyond the control of the contractor may be exempt from the completion requirements if stated as such in writing by the engineer. Such tests shall then be performed as part of the warranty.

2. The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved as required in Part 1, "Submittals."

3.18 CLEANING

A. The contractor shall clean up all debris resulting from his/her activities daily. The contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.

B. At the completion of work in any area, the contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.

C. At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.19 TRAINING

A. Provide training for a designated staff of Owner's representatives. Training shall be provided via self-paced training, web-based or computer-based training, classroom training, or a combination of training methods.

B. Provide course outline and materials according to the "Submittals" article in Part 1 of this specification. Provide one copy of training material per student.

C. The instructor(s) shall be factory-trained and experienced in presenting this material.

D. Classroom training shall be done using a network of working controllers representative of installed hardware.

3.20 CONTROL VALVE INSTALLATION

A. Valve submittals shall be coordinated for type, quantity, size, calculated Cv, pressure drop and piping configuration to ensure compatibility with pipe design.

B. Slip-stem control valves shall be installed so that the stem position is not more than 60 degrees from the vertical up position. Ball type control valves shall be installed with the stem in the horizontal position.

C. Valves shall be installed in accordance with the manufacturer's recommendations.

D. Control valves shall be installed so that they are accessible and serviceable and so that actuators may be serviced and removed without interference from structure or other pipes and/or equipment.

E. Isolation valves shall be installed so that the control valve body may be serviced without draining the supply/return side piping system. Unions shall be installed at all connections to screw-type control valves.

F. Provide tags for all control valves indicating service and number. Tags shall be brass, 1.5 inch in diameter, with ¼ inch high letters. Securely fasten with chain and hook. Match identification numbers as shown on approved controls shop drawings.

3.21 CONTROL DAMPER INSTALLATION

A. Damper submittals shall be coordinated for type, quantity, and size to ensure compatibility with sheet metal design.

B. Duct openings shall be free of any obstruction or irregularities that might interfere with blade or linkage rotation or actuator mounting. Duct openings shall measure ¼ in. larger than damper dimensions and shall be square, straight, and level.

C. Individual damper sections, as well as entire multiple section assemblies, must be completely square and free from racking, twisting, or bending. Measure diagonally from upper corners to opposite lower corners of each damper section. Both dimensions must be within 1/8 in. of each other.

D. Follow the manufacturer's instructions for field installation of control dampers. Unless specifically designed for vertical blade application, dampers must be mounted with blade axis horizontal.

E. Install extended shaft or jackshaft according to manufacturer's instructions. (Typically, a sticker on the damper face shows recommended extended shaft location. Attach shaft on labeled side of damper to that blade.)

F. Damper blades, axles, and linkage must operate without binding. Before system operation, cycle damper after installation to ensure proper operation. On multiple section assemblies, all sections must open and close simultaneously.

G. Provide a visible and accessible indication of damper position on the drive shaft end.

H. Support ductwork in area of damper when required to prevent sagging due to damper weight.

I. After installation of low-leakage dampers with seals, caulk between frame and duct or opening to prevent leakage around perimeter of damper.

3.22 DUCT SMOKE DETECTION

A. Submit data for coordination of duct smoke detector interface to HVAC systems as required in Part 1, "Submittals."

B. This Contractor shall provide a dry-contact alarm output in the same room as the HVAC equipment to be controlled.

3.23 CONTROLS COMMUNICATION PROTOCOL

A. General. The electronic controls packaged with this equipment shall communicate with the building energy management system (DDC). The DDC shall communicate with these controls to read the information and change the control setpoints as shown in the points list, sequences of operation, and control schematics. The information to be communicated between the DDC and these controls shall be in the standard object format as defined in ANSI/ASHRAE Standard 135 (BACnet). Controllers shall communicate with other BACnet objects on the internetwork using the Read (Execute) Property service as defined in Clause 15.5 of Standard 135.

B. Distributed Processing. The controller shall be capable of stand-alone operation and shall continue to provide control functions if the network connection is lost.

C. I/O Capacity. The controller shall contain sufficient I/ O capacity to control the target system.

D. The Controller shall have a physical connection for a laptop computer or a portable operator's tool.

E. Environment. The hardware shall be suitable for the anticipated ambient conditions.

1. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 40 °F to 140 °F.
2. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 32 °F to 120 °F.

F. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field removable, modular terminal strips or to a termination card connected by a ribbon cable.

G. Memory. The Controller shall maintain all BIOS and programming information in the event of a power loss for at least 30 days.

H. Power. Controller shall be able to operate at 90% to 110% of nominal voltage rating.

I. Transformer. Power supply for the Controller must be rated at minimum of 125% of ASC power consumption and shall be fused or current limiting type.

3.24 START-UP AND CHECKOUT PROCEDURES

A. Start up, check out, and test all hardware and software and verify communication between all components.

1. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
2. Verify that all analog and binary input/output points read properly.
3. Verify alarms and interlocks.
4. Verify operation of the integrated system.
5. Verify that all adjustable room temperature setpoints for cooling and heating have software High/Low setpoint limits in place. Limits are 70 Deg (LOW) to 75 Deg (HIGH). Wrestling rooms shall have 70 deg LOW, 80 Deg HIGH. Limits shall be adjustable only by administrator password level.

END OF SECTION 23 09 00

SECTION 23 21 13

HYDRONIC PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. The work covered under this Section of the Specifications is intended to include the furnishing of all equipment, materials and labor or reasonably incidental to the complete operating installation of systems as shown on the plan and of related equipment all as indicated on the drawings, as hereinbefore specified under Division 23 and as hereinafter specified in this Section.

B. Section includes pipe and fitting materials and joining methods for the following:

1. Hot-water heating piping.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. RTRP and RTRF with adhesive.
2. Pressure-seal fittings.
3. Chemical treatment.
4. Grooved joint couplings and fitting shall be referred to on drawings and product submittals, and be identified by the manufacturer's listed model or series designation.

B. Delegated-Design Submittal:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
4. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.04 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.05 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.

B. All grooved couplings, and fittings, valves and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.

1. All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

1. Hot-Water Heating Piping: **120 psig at 200 deg F**

2.02 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Grooved, Mechanical-Joint, Wrought-Copper Fittings: ASME B16.22.

1. Grooved-End Copper Fittings: ASME B16.22 wrought copper or ASTM B 75, copper tube or ASME B16.18 and ASTM B 584, bronze casting. Manufactured to copper-tube dimensions. (Flaring of tube or fitting ends to accommodate alternate sized couplings is not permitted.).
2. Grooved-End-Tube Couplings: Rigid pattern, housings cast with offsetting, angle-pattern, bolt pads; gasketed fitting. Two ductile-iron housing with keys matching pipe and fitting grooves, EPDM-HP gasket rated for minimum 250 deg F for use with housing, and ASTM A449 electroplated steel bolts and nuts.

E. Wrought-Copper Unions: ASME B16.22.

2.03 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

F. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

G. Grooved Mechanical-Joint Fittings and Couplings:

1. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 53/A 53M, Type F, E, or S, Grade B factory-fabricated steel; or ASTM A 234, Grade WPB steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

2. Couplings: Two ductile iron housings and EPDM or nitrile gasket of central cavity pressure-responsive design; with ASTM A449 electroplated steel nuts and bolts, to secure grooved pipe and fittings.

   a. Couplings shall comply with ASTM F1476 – Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications.
   b. Rigid Type: Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with ANSI B31.1, B31.9, with Victaulic Style 107H/107N (Quick-Vic™), Installation ready rigid coupling for direct stab installation without field disassembly. Gasket shall be Grade “EHP” EPDM designed for operating temperatures from -30 deg F (-34 deg C) to +250 deg F (+120 deg C).
   c. Flexible Type: Use in locations where vibration attenuation and stress relief are required. Flexible couplings may be used in lieu of flexible connectors at equipment connections. Three couplings, for each connector, shall be placed in close proximity to the vibration source. Victaulic Style 177 (Quick-Vic™), Installation Ready and Style 77 flexible coupling.
   d. Victaulic AGS Mechanical Couplings, 14 inch (DN350) through 60 inch (DN1500): Couplings shall consist of two ASTM A-536 ductile iron housing segments with lead-in chamfer on housing key and a wide-width elastomer pressure responsive gasket. Victaulic Style W07 AGS Rigid and Style W77 AGS Flexible Coupling.

2.04 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.

   a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
   b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Grooved Joint Lubricants: Lubricate gaskets in accordance with the manufacturer’s published installation instructions, using lubricant compatible with the gasket elastomer and fluid media

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

F. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

G. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.05 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric nipples or 6” minimum length brass nipples.

C. Di-electric Flange kits rated for the system temperature and pressure.

2.06 BYPASS CHEMICAL FEEDER

A. Description: Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves.

1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

PART 3 - EXECUTION

3.01 PIPING APPLICATIONS

A. See schedule on plans.

B. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

C. Air-Vent Piping:

1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

D. Safety-Valve-Inlet and -Outlet Piping for Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

3.02 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using mechanically formed tee fittings or tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

Q. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

R. Unions and flanges for servicing and disconnect are not required in installations with grooved mechanical joint couplings. (The couplings shall serve as disconnect points.)

S. Install shutoff valve immediately upstream of each dielectric fitting.

3.03 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric nipples.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges or flange kits.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

E. Dielectric waterway fittings with grooved and/or threaded ends may be used in lieu of dielectric unions, flanges, or flange-kits in applicable piing systems.

3.04 HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.

B. See schedule on plan.

C. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.05 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

G. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts in accordance with the manufacturer’s published instructions. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings. Grooved ends shall be clean and free from indentations, projections, and roll marks. Gaskets shall be molded and produced by the coupling manufacturer, and shall be verified as suitable for the intended service. A factory-trained field representative (direct employee) of the mechanical joint manufacture shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. The factory-trained representative shall periodically review the product installation and ensure best practices are being followed. Contractor shall remove and replace any improperly installed products. A distributor’s representative is not considered qualified to conduct the training.

H. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.

3.06 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gages for HVAC Piping."

3.07 CHEMICAL TREATMENT

A. All chemical treatment shall be as recommended by the chemical supplier, inhibitors must be added immediately when the system is filled.

B. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.

C. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

D. Fill systems that have glycol solutions with the concentration that is in the system. Contractor MUST test systems and submit report on the glycol type and concentration prior to any work. Contractor to include chemicals as required for the new work.

3.08 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.

2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 23 21 13

SECTION 23 31 13

METAL DUCTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. The work covered under this Section of the Specifications is intended to include the furnishing of all equipment, materials and labor or reasonably incidental to the complete operating installation of systems as shown on the plan and of related equipment all as indicated on the drawings, as hereinbefore specified under Division 23 and as hereinafter specified in this Section.

B. Section Includes:

1. Rectangular ducts and fittings.
2. Round ducts and fittings.
3. Sheet metal materials.
4. Sealants and gaskets.
5. Hangers and supports.

1.03 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article. All ducts shall be a minimum of thickness of 26 gage.

B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.

7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment and vibration isolation.

C. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:

a. Lighting fixtures.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.
f. Perimeter moldings.

B. Welding certificates.

1.06 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.01 RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.02 ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.03 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct

construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G60.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

D. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

E. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.04 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 3 inches.
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.05 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

F. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

G. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

PART 3 - EXECUTION

3.01 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

3.02 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.03 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.04 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.05 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.06 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.07 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

1. Underground Ducts: Concrete-encased, PVC-coated, galvanized sheet steel with thicker coating on duct exterior.

B. See schedule on plans.

C. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.
2. PVC-Coated Ducts:

a. Exposed to Airstream: Match duct material.
b. Not Exposed to Airstream: Match duct material.

D. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Velocity 1000 fpm or Lower:

1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
2) Mitered Type RE 4 without vanes.

b. Velocity 1000 to 1500 fpm:

1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

c. Velocity 1500 fpm or Higher:

1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.

3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
4) Radius-to Diameter Ratio: 1.5.

b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam or Welded.

E. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

a. Rectangular Main to Rectangular Branch: 45-degree entry.
b. Rectangular Main to Round Branch: Spin in.

2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

a. Velocity 1000 fpm or Lower: 90-degree tap.
b. Velocity 1000 to 1500 fpm: Conical tap.
c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 23 31 13

SECTION 23 33 00

AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Manual volume dampers.
3. Control dampers.
4. Fire dampers.
5. Smoke dampers.
6. Flange connectors.
7. Turning vanes.
8. Duct-mounted access doors.
9. Flexible connectors.
10. Flexible ducts.
11. Duct accessory hardware.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

a. Special fittings.
b. Manual volume damper installations.
c. Control-damper installations.
d. Fire-damper and smoke-damper installations, including sleeves; and duct-mounted access doors.
e. Wiring Diagrams: For power, signal, and control wiring.

1.03 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.01 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless

otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.02 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G60, with G90 for all outdoor and high moisture areas including shower areas, locker rooms, etc.
2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and No.3 finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.03 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Description: Gravity balanced.

B. Maximum Air Velocity: 2000 fpm

C. Maximum System Pressure: 2-inch wg.

D. Frame: Hat-shaped, 0.05-inch- thick, galvanized sheet steel, mechanically attached and mounting flange.

E. Blades: Multiple single-piece blades, end pivoted, maximum 6-inch width, 0.025-inch-thick, roll-formed aluminum with sealed edges.

F. Blade Action: Parallel.

G. Blade Seals: Extruded vinyl or Neoprene, mechanically locked.

H. Blade Axles:

1. Material: Stainless steel

I. Tie Bars and Brackets: Aluminum

J. Return Spring: Adjustable tension.

K. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.

2. Counterweights and spring-assist kits for vertical airflow installations.
3. Electric actuators.
4. Chain pulls.
5. Screen Mounting: Front mounted in sleeve.

    a. Sleeve Thickness: 20 gage minimum.
    b. Sleeve Length: 6 inches minimum.

6. Screen Mounting: Rear mounted.
7. Screen Material: Aluminum.
8. Screen Type: Insect.
9. 90-degree stops.

2.04 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Standard leakage rating**,** with linkage outside airstream.
2. Suitable for horizontal or vertical applications.
3. Frames:

    a. Frame: Hat-shaped, 0.094-inch- thick, galvanized sheet steel or 0.05-inch- thick stainless steel.
    b. Mitered and welded corners.
    c. Flanges for attaching to walls and flangeless frames for installing in ducts.

4. Blades:

    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Stiffen damper blades for stability.
    d. Galvanized or Stainless-steel, 0.064 inch thick.

5. Blade Axles: Galvanized steel or Stainless steel.

    a. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

6. Tie Bars and Brackets: Galvanized steel.

B. Standard, Aluminum, Manual Volume Dampers:

1. Standard leakage rating, with linkage outside airstream.
2. Suitable for horizontal or vertical applications.
3. Frames: Hat-shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
4. Blades:

    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Stiffen damper blades for stability.
    d. Roll-Formed Aluminum Blades: 0.10-inch- thick aluminum sheet.
    e. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.

5. Blade Axles: Nonferrous metal.

   a. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

6. Tie Bars and Brackets: Aluminum.

C. Jackshaft:

1. Size: 0.5-inch or 1-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

D. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.05 CONTROL DAMPERS

A. Frames:

1. Material to match duct material
2. Interlocking, gusseted corners.

B. Blades:

1. Multiple blade with maximum blade width of 8 inches.
2. Parallel- and opposed-blade design.
3. Galvanized-steel or Stainless steel or Aluminum.
4. Blade Edging: Closed-cell neoprene or PVC.
5. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.

C. Blade Axles: 1/2-inch- diameter; same material as damper; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.

1. Operating Temperature Range: From minus 40 to plus 200 deg F.
2. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
3. Thrust bearings at each end of every blade.

2.06 FIRE DAMPERS

A. Type: Dynamic rated and labeled according to UL 555 by an NRTL. Material shall match connecting duct.

B. Closing rating in ducts up to 2-inch wg static pressure class and minimum 2000-fpm velocity. All dampers shall be rated to close in vertical or horizontal applications.

C. Fire Rating: 1-1/2 hours.

D. Frame: Curtain type with blades outside airstream or Multiple-blade type; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners without welded joints.

E. Mounting Sleeve: Factory- or field-installed, material to match ductwork.

1. Minimum Thickness: As required by manufacturer to suit application.
2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

F. Mounting Orientation: Vertical or horizontal as indicated. All dampers shall be rated to close in vertical or horizontal applications.

G. Blades: Roll-formed, with material to match ductwork.

H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

I. Heat-Responsive Device: Replaceable (or resettable), 165 deg F rated, fusible links. If immediately downstream of a heating coil / heater then coordinate as 212 may be required.

2.07 SMOKE DAMPERS

A. General Requirements: Label according to UL 555S by an NRTL. Material shall match connecting duct.

B. Smoke Detector: Integral, factory wired for single-point connection.

C. Frame:

1. Material to match duct material
2. Mechanically attached corners and mounting flange.

D. Blades: Roll-formed, horizontal blades with material to match ductwork.

1. Blade seals shall be silicone and rated to 350 degrees F.

E. Leakage: Class I

F. Rated pressure and velocity to exceed design airflow conditions.

G. Mounting Sleeve: Factory- or field-installed, material to match ductwork.

H. Damper Motors: two-position action. Dampers shall be fail close unless indicated otherwise.

I. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230900 "Instrumentation and Control for HVAC."
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
7. Electrical Connection: 115 V, single phase, 60 Hz.

J. Accessories:

1. Auxiliary switches for position indication.
2. Momentary test switch mounted.

2.08 FLANGE CONNECTORS

A. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components. Foam tape and plastic cleats and not acceptable.

B. Material: Galvanized steel.

C. Gage and Shape: Match connecting ductwork.

2.09 TURNING VANES

A. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

B. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

D. Vane Construction: Double wall.

2.10 DUCT-MOUNTED ACCESS DOORS

A. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:

    a. Double wall, rectangular.
    b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
    c. Vision panel.
    d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
    e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:

    a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
    b. Access Doors up to 18 Inches Square: Two hinges or continuous hinge and two sash locks.
    c. Access Doors up to 24 by 48 Inches: Three hinges or Continuous hinge and two compression latches with outside handles.
    d. Access Doors Larger Than 24 by 48 Inches: Four hinges or Continuous hinge and two compression latches with outside and inside handles.

B. Pressure Relief Access Door:

1. Door and Frame Material: Galvanized sheet steel.
2. Door: Single wall or Double wall with insulation fill with metal thickness applicable for duct pressure class.
3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
4. Factory set at 3.0- to 8.0-inch wg
5. Doors close when pressures are within set-point range.
6. Hinge: Continuous piano.
7. Latches: Cam.
8. Seal: Neoprene or foam rubber.
9. Insulation Fill: 1-inch- thick, fibrous-glass or polystyrene-foam board.

2.11 DUCT ACCESS PANEL ASSEMBLIES

A. Labeled according to UL 1978 by an NRTL.

B. Panel and Frame: Minimum thickness 0.0528-inch carbon or 0.0428-inch stainless steel.

C. Fasteners: Carbon Steel with Stainless steel used in all aluminum and stainless steel ducts. Panel fasteners shall not penetrate duct wall.

D. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

E. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.12 FLEXIBLE CONNECTORS

A. Materials: Flame-retardant or noncombustible fabrics.

B. Coatings and Adhesives: Comply with UL 181, Class 1.

C. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches or 5-3/4 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.

D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd.
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd.
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

2.13 FLEXIBLE DUCTS

A. Noninsulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 10 to plus 160 deg F.

B. Insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene or aluminized vapor-barrier film.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 210 deg F.
4. Insulation R-value: Comply with ASHRAE/IESNA 90.1.

C. Flexible Duct Connectors:

1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action or Nylon strap in sizes 3 through 18 inches, to suit duct size.

2.14 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft or control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire dampers according to UL listing and manufacturers recommendations.

H. Install duct access and smoke doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. At outdoor-air intakes and mixed-air plenums.
3. At drain pans and seals.
4. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
5. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
6. Upstream or downstream from duct silencers.
7. Control devices requiring inspection.
8. Elsewhere as indicated.

I. Install access doors with swing against duct static pressure.

J. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches.
2. Two-Hand Access: 12 by 6 inches.
3. Head and Hand Access: 18 by 10 inches.
4. Head and Shoulders Access: 21 by 14 inches.
5. Body Access: 25 by 14 inches.

6. Body plus Ladder Access: 25 by 17 inches.

K. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

L. Install flexible connectors to connect ducts to equipment.

M. Connect terminal units to supply ducts with maximum 36-inch lengths of flexible duct. Do not use flexible ducts to change directions.

N. Connect diffusers or to ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place. Hard elbow shall be installed directly on diffuser.

O. Install duct test holes where required for testing and balancing purposes.

3.02 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.

END OF SECTION 23 33 00

SECTION 23 36 00

AIR TERMINAL UNITS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
1. Shutoff, single-duct air terminal units.
2. Shutoff, Dual-duct air terminal units
3. Casing liner.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of air terminal unit.

B. Shop Drawings: For air terminal units.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Hangers and supports, including methods for duct and building attachment and vibration isolation.

1.03 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.04 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of equipment that fails in materials or workmanship within specified warranty period.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

2.02 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

A. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

B. Casing: 0.40-inches thick galvanized steel, single wall.

1. Casing Liner: Comply with requirements in "Casing Liner" Article for fibrous-glass, flexible elastomeric duct liner.
2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, 3 percent of nominal airflow at 3-inch wg inlet static pressure.
2. Damper Position: Normally open

D. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve.

E. Control devices shall be compatible with temperature controls system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

1. Electric Damper Actuator: 24 V, powered open, spring return.
2. Electronic Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg; and shall have a multipoint velocity sensor at air inlet.
3. Terminal Unit Controller: Pressure-independent, variable-air-volume (VAV) controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:

    a. Occupied and unoccupied operating mode.
    b. Remote reset of airflow or temperature set points.
    c. Adjusting and monitoring with portable terminal.
    d. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

F. Controls:

1. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg inlet static pressure.

2.03 SHUTOFF, DUAL-DUCT AIR TERMINAL UNITS

A. Configuration: dual Volume-damper assemblies inside unit casing, one for cold air and one for hot air, with control components inside a protective metal shroud. Dampers modulate or shut off air from each duct to meet zone temperature requirements.

B. Casing: 0.40-inches thick galvanized steel, single wall.

1. Casing Liner: Comply with requirements in "Casing Liner" Article for fibrous-glass, flexible elastomeric duct liner.
2. Air Inlets (Cold and Hot): Round stub connection or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Volume Damper (Cold and Hot Ducts): Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, 3 percent of nominal airflow at 3-inch wg inlet static pressure.
2. Damper Position: Normally open

D. Control devices shall be compatible with temperature controls system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

1. Electric Damper Actuators (Cold and Hot): 24 V, powered open, spring return.
2. Electronic Velocity Controller (Cold and Hot): Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg; and shall have a multipoint velocity sensor at air inlet.
3. Terminal Unit Controller: Pressure-independent, variable-air-volume (VAV) controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:

    a. Occupied and unoccupied operating mode.
    b. Remote reset of airflow or temperature set points.
    c. Adjusting and monitoring with portable terminal.
    d. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

E. Controls:

1. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg inlet static pressure.Retain “Control Sequence” Paragraph below if control sequences are not specified in Section 230993.11 “Sequence of Operations for HVAC DDC.”

2.04 CASING LINER

A. Casing Liner: Fibrous-glass duct liner, complying with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Minimum Thickness: 1”

    a. Maximum Thermal Conductivity:

        1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
        2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

2. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C916.

2.05 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to AHRI 880.

1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows,and AHRI certification seal.

PART 3 - EXECUTION

3.01 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 5, "Hangers and Supports" and with Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.02 TERMINAL UNIT INSTALLATION

A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

C. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.

D. Hot-Water Piping: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties," and connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

E. Make connections to air terminal units with flexible connectors .

F. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.03 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Air terminal unit will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.04 DEMONSTRATION

1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 23 36 00

Appendix

FOR

Omaha Public Schools – Blackburn High School
HVAC Improvements

<u>Files:</u>

Reviewed Shop Drawings from previous 2021 project designed by others and all work completed. Files are included for informational purposes only. These files are not part of the new design, but provided for reference to the existing system.

Project: W156700 OPS- ADAMS & BLACKBURN GC
2602 HAMILTON ST
OMAHA, Nebraska 68131

Submittal #23 09 00-1.0 - HVAC Direct Digital Controls Product Data and Shop Drawings
23 09 00 - HVAC Direct Digital Controls

Revision	0	**Submittal Manager**	Kristin Larsen (THE WEITZ COMPANY - NEBRASKA)
Status	In Review	**Date Created**	Mar 12, 2021
Issue Date		**Spec Section**	23 09 00 - HVAC Direct Digital Controls
Responsible Contractor	RAY MARTIN COMPANY OF OMAHA	**Received From**	Ken Jambor (RAY MARTIN COMPANY OF OMAHA)
Received Date		**Submit By**	
Final Due Date	May 4, 2021	**Lead Time**	
Sub Job		**Cost Code**	
Location		**Type**	Product Data
Approvers	Kristin Larsen (THE WEITZ COMPANY - NEBRASKA), Kei'lah Sadler (THE WEITZ COMPANY - NEBRASKA), Chad Liechti (KPE CONSULTING ENGINEERS INC)		
Ball in Court	Chad Liechti (KPE CONSULTING ENGINEERS INC)		
Distribution			
Description			

Submittal Workflow

Name	Sent Date	Due Date	Returned Date	Response	Attachments
General Information Attachments					
Ken Jambor	May 21, 2021	Apr 2, 2021	May 21, 2021	Submitted	VALVE SUBMITTAL.pdf
Kristin Larsen	May 21, 2021	Apr 20, 2021	May 21, 2021	Approved	23 0900-001-00 Controls Valves and Actuators Product Data.pdf (Current)
Kei'lah Sadler	May 21, 2021	Apr 20, 2021		Pending	
Chad Liechti	May 21, 2021	May 4, 2021		Pending	

WEITZ

Nebraska Office
8715 S. 121st Street
LaVista, Nebraska 68128

SUBMITTAL REVIEW

The Weitz Companies review ONLY covers coordination of work and layout. Conformance with design concept documents is not checked. Weitz review does not relieve the subcontractor and/or supplier of their contractual requirements. Subcontractor must confirm that the material and equipment meets all contractual requirements.

☑ Reviewed ☐ Reviewed & Noted ☐ Rejected

By: LarsenK Date: 05/21/2021

Submittal No: 23 0900-001-00 Controls Valves and Actuators Product Data

13326 "C" Street, Omaha, NE 68144-3602
Telephone: (402) 333-9800 Fax: (402) 333-9881

VALVE AND ACTUATOR

SUBMITTALS

OPS BLACKBURN

13326 "C" Street, Omaha, NE 68144-3602
Telephone: (402) 333-9800 Fax: (402) 333-9881

May 13, 2021

VALVE SCHEDULE

QTY	SYSTEM	Location	Serves	LINE SIZE IN	VALVE SIZE IN.	HW/CW STEAM ?	2W OR 3W	GPM MAX	VALVE CV	ADJ. CV	VALVE PD PSI WATER	PART NUMBER	VALVE TYPE
1	Fin Tube	Room 100	Room 100	0.5	0.5	HW	2w	2.4	1.9	1.9	1.60	22560JF-CQ024-SR-R	Ball
1	Fin Tube	Room 103	Room 103	0.5	0.5	HW	2w	2.4	1.9	1.9	1.60	22560JF-CQ024-SR-R	Ball
1	Fin Tube	Room 104	Room 104	0.5	0.5	HW	2w	2.4	1.9	1.9	1.60	22560JF-CQ024-SR-R	Ball
1	Unit Heater	Room 105	Room 105	0.5	0.5	HW	2w	2.4	1.9	1.9	1.60	22560JF-CQ024-SR-R	Ball
1	Fan Coil	Room 107	Room 107	0.5	0.5	HW	2w	2.4	1.9	1.9	1.60	22560JF-CQ024-SR-R	Ball
1	Fan Coil	Room 150	Room 150	0.5	0.5	HW	2w	2.4	1.9	1.9	1.60	22560JF-CQ024-SR-R	Ball
1	Unit Heater	Room 167	Room 167	0.5	0.5	HW	2w	2.4	1.9	1.9	1.60	22560JF-CQ024-SR-R	Ball
1	Unit Heater	Room 168	Room 168	0.5	0.5	HW	2w	2.4	1.9	1.9	1.60	22560JF-CQ024-SR-R	Ball
1	Fin Tube	Room 201	Room 201	0.5	0.5	HW	2w	2.4	1.9	1.9	1.60	22560JF-CQ024-SR-R	Ball
1	Reheat Box	Room 107	Room 107	0.5	0.5	HW	2w	4	2.3	2.3	3.02	22560JF-CQ024-3	Ball
1	Reheat Box	Room 124	Room 124	0.5	0.5	HW	2w	4	2.3	2.3	3.02	22560JF-CQ024-3	Ball
1	Fin Tube	Room 332	Room 332	0.5	0.5	HW	2w	4	2.3	2.3	3.02	22560JF-CQ024-3	Ball
1	Fin Tube	Room 343	Room 343	0.5	0.5	HW	2w	2.4	1.9	1.9	1.60	22560JF-CQ024-SR-R	Ball
1	Fin Tube	Room 344	Room 344	0.5	0.5	HW	2w	2.4	1.9	1.9	1.60	22560JF-CQ024-SR-R	Ball
1	Fin Tube	Room 158	Room 158	0.5	0.5	HW	2w	4	2.3	2.3	3.02	22560JF-CQ024-3	Ball
1	Unit Heater	Room 172	Room 173	0.75	0.75	HW	2w	6	3.3	3.3	3.01	22575JA-CQ024-SR-R	Ball
1	Unit Heater	Room 191	Room 191	0.75	0.75	HW	2w	6	3.3	3.3	5.88	22575JA-CQ024-SR-R	Ball
1	Reheat Box	Room 100	Room 100	0.5	0.5	HW	2w	1	1.6	1.6	0.35	22560JF-CQ024-SR-R	Ball
1	Reheat Box	Room 106	Room 106	0.5	0.5	HW	2w	1	1.6	1.6	0.39	22560JF-CQ024-SR-R	Ball
1	Reheat Box	Room 107	Room 107	0.5	0.5	HW	2w	1	1.6	1.6	0.78	22560JF-CQ024-SR-R	Ball
1	Fin Tube	Room 107	Room 107	0.5	0.5	HW	2w	1	1.6	1.6	0.35	22560JF-CQ024-SR-R	Ball
1	Reheat Box	Room 109	Room 109	0.5	0.5	HW	2w	1	1.6	1.6	0.39	22560JF-CQ024-SR-R	Ball
1	Reheat Box	Room 111	Room 111	0.5	0.5	HW	2w	1	1.6	1.6	0.78	22560JF-CQ024-SR-R	Ball
1	Reheat Box	Room 116	Room 116	0.5	0.5	HW	2w	1	1.6	1.6	0.35	22560JF-CQ024-SR-R	Ball
1	Reheat Box	Room 117	Room 117	0.5	0.5	HW	2w	1	1.6	1.6	0.39	22560JF-CQ024-SR-R	Ball
1	Reheat Box	Room 118	Room 118	0.5	0.5	HW	2w	1	1.6	1.6	0.35	22560JF-CQ024-SR-R	Ball
1	Fin Tube	Room 124	Room 124	0.5	0.5	HW	2w	1	1.6	1.6	0.39	22560JF-CQ024-SR-R	Ball

13326 "C" Street, Omaha, NE 68144-3602
Telephone: (402) 333-9800 Fax: (402) 333-9881

QTY	SYSTEM	Location	Serves	LINE SIZE IN.	VALVE SIZE IN.	STEAM ?	2W DR 3W	GPM @HR	VALVE CV	ADJ CV	VALVE PD PSI WATER	PART NUMBER	VALVE TYPE
1	Fin Tube	Room 124	Room 124	0.5	0.5	HW	2W	1	1.6	1.6	0.39	ZX060D-F+CQB24-SR-R	Ball
1	Fin Tube	Room 203	Room 203	0.5	0.5	HW	2W	1	1.6	1.6	0.39	ZX060D-F+CQB24-SR-R	Ball
1	Reheat Box	Room 204	Room 204	0.5	0.5	HW	2W	1	1.6	1.6	0.39	ZX060D-F+CQB24-SR-R	Ball
1	Reheat Box	Room 207	Room 207	0.5	0.5	HW	2W	1	1.6	1.6	0.39	ZX060D-F+CQB24-SR-R	Ball
1	Reheat Box	Room 213	Room 213	0.5	0.5	HW	2W	1	1.6	1.6	0.39	ZX060D-F+CQB24-SR-R	Ball
1	Reheat Box	Room 216	Room 216	0.5	0.5	HW	2W	1	1.6	1.6	0.39	ZX060D-F+CQB24-SR-R	Ball
1	Reheat Box	Room 230	Room 230	0.5	0.5	HW	2W	1	1.6	1.6	0.39	ZX060D-F+CQB24-SR-R	Ball
1	Reheat Box	Room 232	Room 232	0.5	0.5	HW	2W	1	1.6	1.6	0.39	ZX060D-F+CQB24-SR-R	Ball
1	Reheat Box	Room 233	Room 233	0.5	0.5	HW	2W	1	1.6	1.6	0.39	ZX060D-F+CQB24-SR-R	Ball
1	Reheat Box	Room 236	Room 236	0.5	0.5	HW	2W	1	1.6	1.6	0.39	ZX060D-F+CQB24-SR-R	Ball
1	Reheat Box	Room 327	Room 327	0.5	0.5	HW	2W	1	1.6	1.6	0.39	ZX060D-F+CQB24-SR-R	Ball
1	Reheat Box	Room 332	Room 332	0.5	0.5	HW	2W	1	1.6	1.6	0.39	ZX060D-F+CQB24-SR-R	Ball
1	Reheat Box	Room 332	Room 332	0.5	0.5	HW	2W	1	1.6	1.6	0.39	ZX060D-F+CQB24-SR-R	Ball
1	Reheat Box	Room 333	Room 333	0.5	0.5	HW	2W	1	1.6	1.6	0.39	ZX060D-F+CQB24-SR-R	Ball
1	Reheat Box	Room 336	Room 336	0.5	0.5	HW	2W	1	1.6	1.6	0.39	ZX060D-F+CQB24-SR-R	Ball
1	Common Areas	AHU 5	AHU 5	2	2	HW	2W	68	46	46	2.13	B245+AFRB24-SR	Ball
1	Common Areas	AHU 5	AHU 5	2.5	2.5	CW	2W	170	70	70	2.12	B2565-00+AFRB24-SMFT-S	Ball
1	Gym	AHU 6	AHU 6	2.5	2.5	HW	2W	105	70	70	2.25	B2565-00+AFRB24-SMFT-S	Ball
1	Gym	AHU 6	AHU 6	2.5	2.5	CW	2W	105	70	70	2.29	B2565-00+AFRB24-SMFT-S	Ball
1	Lecture	AHU 7	AHU 7	1.25	1.25	HW	2W	35	18	18	1.92	B230+LF24-MFT-S US	Ball
1	Lecture	AHU 7	AHU 7	1.25	1.25	CW	2W	41	29	29	2.00	B235+AFRB24-SR	Ball
1	Kitchen Dining	AHU 8	AHU 8	1	1	HW	2W	20	10	10	1.60	B220+LF24-MFT-S US	Ball
1	Kitchen Dining	AHU 8	AHU 8	1.25	1.25	CW	2W	30	18	18	2.48	B230+LF24-MFT-S US	Ball
1	Kitchen Dining	AHU 8	AHU 8	0.75	0.75	HW	2W	11	7.4	7.4	1.83	B210+LF24-MFT-S US	Ball
1	Day Care	AHU 9	AHU 9	1	1	HW	2W	10	10	10	1.05	B220+LF24-MFT-S US	Ball
1	Day Care	AHU 9	AHU 9	1.25	1.25	CW	2W	30	18	18	2.48	B230+LF24-MFT-S US	Ball
1	Art and Music	AHU 10	AHU 10	1.5	1.5	HW	2W	45	28	28	2.40	B239+AFRB24-SR	Ball

May 19, 2021

VALVE SCHEDULE

QTY	SYSTEM	Location	Serves	LINE SIZE IN.	VALVE SIZE IN.	HW/CW STEAM ?	2W DR 3W	GPM @HR	VALVE CV	ADJ CV	VALVE PD PSI WATER	PART NUMBER	VALVE TYPE
1	Art and Music	AHU 10	AHU 10	1.5	1.5	HW	2W	45	28	28	2.40	B239+AFRB24-SR	Ball
1	Art and Music	AHU 10	AHU 10	1.5	1.5	CW	2W	67	29	29	2.67	B239+AFRB24-SR	Ball
1	Women Locker Room	AHU 11	AHU 11	1	1	HW	2W	15	10	10	1.63	B220+LF24-MFT-S US	Ball
1	Mens Locker Room	AHU 12	AHU 12	1	1	HW	2W	15	10	10	1.63	B220+LF24-MFT-S US	Ball
1	Weeding	AHU 13	AHU 13	1	1	HW	2W	15	10	10	1.63	B220+LF24-MFT-S US	Ball
1	Kitchen MAU	AHU 14	AHU 14	1.25	1.25	HW	2W	28	18	18	2.12	B230+LF24-MFT-S US	Ball

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VALVE AND ACTUATOR

CUTSHEETS

OPS BLACKBURN

BELIMO

Stainless Steel Ball and Stem

Technical data sheet B218

5-year warranty

Technical data

Functional data	Valve Size	0.75" [20]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	0...250°F [-18...120°C]
	Body Pressure Rating	600 psi
	Close-off pressure Δps	200 psi
	Flow characteristic	equal percentage
	Servicing	maintenance-free
	Flow Pattern	2-way
	Leakage rate	0% for A – AB
	Controllable flow range	75°
	Cv	7.4
	Body pressure rating note	600 psi
	Cv Flow Rating	A-port: as stated in chart B-port: 70% of A – AB Cv
Materials	Valve body	Nickel-plated brass body
	Stem seal	EPDM (lubricated)
	Seat	PTFE
	Pipe connection	NPT female ends
	O-ring	EPDM (lubricated)
	Ball	stainless steel
Suitable actuators	Non-Spring	TR LRB(X) NR

Safety notes

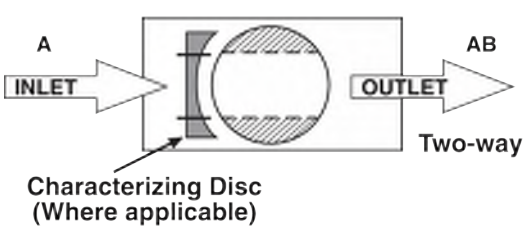
- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov

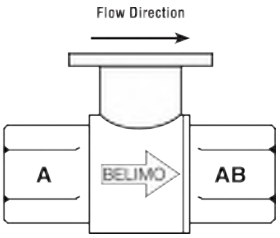
Product features

Application

This valve is typically used in air handling units on heating or cooling coils, and fan coil unit heating or cooling coils. Some other common applications include Unit Ventilators, VAV box re-heat coils and bypass loops. This valve is suitable for use in a hydronic system with variable flow.

Flow/Mounting details

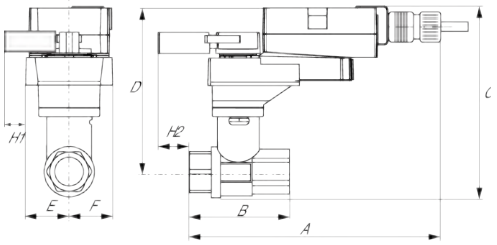




Dimensions

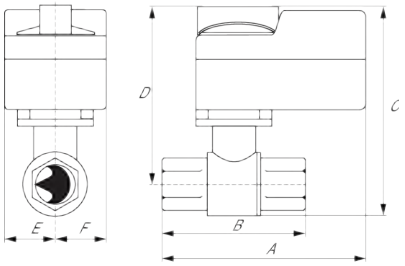
Dimensional drawings

LRB, LRX



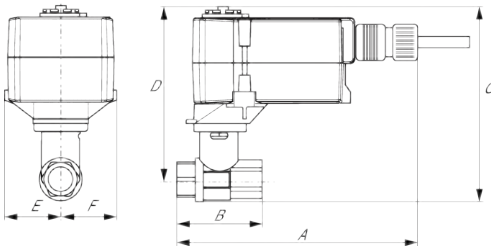
A	B	C	D	E	F	H1	H2
9.4" [239]	2.7" [69]	5.8" [147]	5.1" [129]	1.3" [33]	1.3" [33]	1.2" [30]	1" [25]

TR



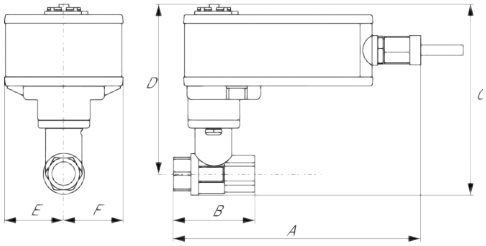
A	B	C	D	E	F
4.0" [102]	2.7" [69]	5.4" [137]	5.1" [129]	1.3" [33]	1.3" [33]

TFRB, TFRX



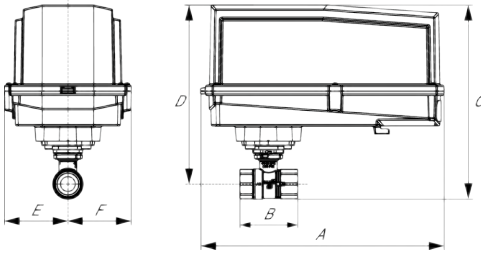
A	B	C	D	E	F
7.0" [178]	2.7" [69]	5.5" [139]	4.8" [122]	1.5" [39]	1.5" [39]

LF



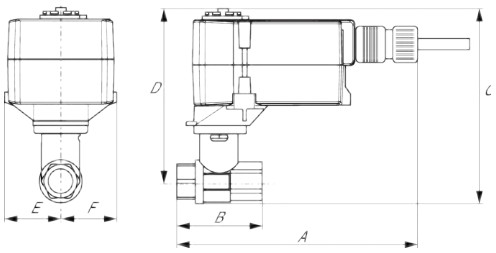
A	B	C	D	E	F
8.6" [218]	2.7" [69]	6.3" [159]	5.6" [142]	1.8" [46]	1.8" [46]

ARB N4, ARX N4, NRB N4, NRX N4



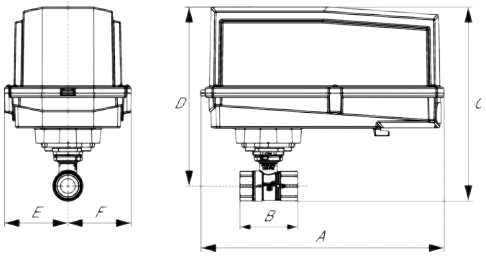
A	B	C	D	E	F
11.4" [289]	2.7" [69]	7.8" [199]	7.1" [181]	3.1" [80]	3.1" [80]

TFRB, TFRX



A	B	C	D	E	F
7.0" [178]	2.7" [69]	5.5" [139]	4.8" [122]	1.5" [39]	1.5" [39]

ARB N4, ARX N4, NRB N4, NRX N4



A	B	C	D	E	F
11.4" [289]	2.7" [69]	7.8" [199]	7.1" [181]	3.1" [80]	3.1" [80]

BELIMO

Modulating, Spring Return, 24 V, Multi-Function Technology®

Proportional, Spring Return, Multi-Function Technology®, Torque min. 35 in-lb, Control 2 to 10 VDC (DEFAULT), Feedback 2 to 10 VDC (DEFAULT)

Technical data sheet LF24-MFT-S US

5-year warranty

MFT

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	2.5 W
	Power consumption in rest position	1 W
	Transformer sizing	5 VA (class 2 power source)
	Auxiliary switch	1 x SPDT, 3 A resistive (0.5 A inductive) @ AC 250 V, adjustable 0...95°
	Switching capacity auxiliary switch	3 A resistive (0.5 A inductive) @ AC 250 V
	Electrical Connection	(2) 18 GA appliance cables with 1/2" conduit connectors, 3 ft [1 m],
	Overload Protection	electronic throughout 0...95° rotation
	Electrical Protection	actuators are double insulated
Functional data	Torque motor	35 in-lb [4 Nm]
	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for 2...10 V (0.1 mA), 500 Ω for 4...20 mA, 1500 Ω for PWM, On/Off and Floating point
	Operating range Y variable	Start point 0.5...30 V End point 2.5...32 V
	Options positioning signal	variable (VDC, PWM, on/off, floating point)
	Position feedback U	2...10 V
	Position feedback U note	Max. 0.5 mA
	Position feedback U variable	VDC variable
	Direction of motion motor	selectable with switch 0/1
	Direction of motion fail-safe	reversible with cw/ccw mounting
	Angle of rotation	Max. 95°, adjustable with mechanical stop
	Angle of rotation note	adjustable with mechanical stop
	Running Time (Motor)	default 150 s, variable 75...300 s
	Running time motor variable	75...300 s
	Running time fail-safe	<25 s @ -4...122°F [-20...50°C], <60 s @ -22°F [-30°C]
	Angle of rotation adaptation	off (default)
	Override control	MIN (minimum position) = 0% MID (intermediate position) = 50% MAX (maximum position) = 100%
	Noise level, motor	30 dB(A)
	Noise level, fail-safe	62 dB(A)
	Shaft Diameter	3/8...1/2" round, centers on 1/2"
	Position indication	Mechanical
Safety data	Degree of protection IEC/EN	IP54

	Degree of protection NEMA/UL	NEMA 2 UL Enclosure Type 2
	Agency Listing	cULus acc. To UL 873 and CAN/CSA C22.2 No. 24-93
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	3.3 lb [1.5 kg]
Materials	Housing material	galvanized steel

Product features

Default/Configuration

Default parameters for 2 to 10 VDC applications of the LF..-MFT actuator are assigned during manufacturing. If required, custom versions of the actuator can be ordered. The parameters are variable and can be changed by three means: Factory pre-set or custom configuration, set by the customer using PC-Tool software or the handheld ZTH US.

Application

For fail-safe, modulating control of dampers in HVAC systems. Actuator sizing should be done in accordance with the damper manufacturer's specifications. A feedback signal is provided for position indication.

Operation

The LF24-MFT US actuator provides 95° of rotation and is provided with a graduated position indicator showing 0° to 95°. The actuator will synchronize the 0° mechanical stop or the damper or valves mechanical stop and use this point for its zero position during normal control operations. The actuator uses a brushless DC motor which is controlled by an Application Specific Integrated Circuit (ASIC) and a microprocessor. The microprocessor provides the intelligence to the ASIC to provide a constant rotation rate and to know the actuator's exact position. The ASIC monitors and controls the brushless DC motor's rotation and provides a Digital Rotation Sensing (DRS) function to prevent damage to the actuator in a stall condition. The position feedback signal is generated without the need for mechanical feedback potentiometers using DRS. The actuator may be stalled anywhere in its normal rotation without the need of mechanical end switches. The LF24-MFT US is mounted directly to control shafts up to 3/4" diameter (K6-1 clamp) and anti-rotation bracket. A crank arm and several mounting brackets are available for damper applications where the actuator cannot be direct coupled to the damper shaft. The spring return system provides minimum specified torque to the application during a power interruption. The LF24-MFT US actuator is shipped in the zero position, compression against seats or gaskets for tight shut-off is accomplished manually.

Typical specification

Spring return control damper actuators shall be direct coupled type which require no crank arm and linkage and be capable of direct mounting to a shaft up to a 3/4" diameter and center on a 1/2" shaft (default). Actuator shall deliver a minimum output torque of 35 in-lbs. The actuator must provide modulating damper control in response to a 2 to 10 VDC or, with the addition of a 500Ω resistor, a 4 to 20 mA control input from an electronic controller or positioner. The actuators must be designed so that they may be used for either clockwise or counter clockwise fail-safe operation. Actuators shall use a brushless DC motor controlled by a microprocessor and be protected from overload at all angles of rotation. Run time shall be constant, and independent of torque. A 2 to 10 VDC feedback signal shall be provided for position feedback. Actuators with auxiliary switches must be constructed to meet the requirements for Double Insulation so an electrical ground is not required to meet agency listings. Actuators shall be cULus listed and have a 5 year warranty, and be manufactured under ISO 9001 International Quality Control Standards. Actuators shall be as manufactured by Belimo.

Factory settings

Default parameters for 2 to 10 VDC applications of the LF..-MFT actuator are assigned during manufacturing. If required, custom versions of the actuator can be ordered. The parameters are variable and can be changed by three means: Factory pre-set or custom configuration, set by the customer using PC-Tool software or the handheld ZTH US.

Accessories

Gateways

Description	Type
Gateway MP to BACnet MS/TP	UK24BAC
Gateway MP to LonWorks	UK24LON
Gateway MP to Modbus RTU	UK24MOD

Electrical accessories

Description	Type
DC Voltage Input Rescaling Module	IRM-100
Belimo PC-Tool, Software for adjustments and diagnostics	MFT-P
Auxiliary switch, mercury-free	P475
Auxiliary switch, mercury-free	P475-1
Signal Siumlator, Power supply AC 230 V	PS-100
Convert Pulse Width Modulated Signal to a 2...10 V Signal for Belimo Proportional Actuators	PTA-250
Positioner for wall mounting	SGA24
Positioner for front-panel mounting	SGF24
Gateway MP to BACnet MS/TP	UK24BAC
Gateway MP to LonWorks	UK24LON
Gateway MP to Modbus RTU	UK24MOD
Conduit box converter	ZG-CBLS
Resistor, 500 Ω, 1/4" wire resistor with 6" pigtail wires	ZG-R01
Resistor Kit, 50% voltage divider	ZG-R02
Mounting plate for SGF.	ZG-SGF
Transformer, AC 120 V to AC 24 V, 40 VA	ZG-X40
Connection cable 16 ft [5 m], A: RJ11 6/4 ZTH EU, B: free wire end for connection to MP/PP terminal	ZK2-GEN
Service Tool, with ZIP-USB function, for parametrisable and communicative Belimo actuators, VAV controller and HVAC performance devices	ZTH US

Mechanical accessories

Description	Type
Shaft extension 170 mm Ø10 mm for damper shaft Ø 6...16 mm	AV6-20
End stop indicator	IND-LF
Shaft clamp for LF..	K6 US
Shaft clamp reversible, clamping range Ø16...20 mm	K6-1
Ball joint suitable for damper crank arm KH8 / KH10	KG10A
Ball joint suitable for damper crank arm KH8	KG6
Ball joint suitable for damper crank arm KH8	KG8
Actuator arm, clamping range Ø8...16 mm, Slot width 8.2 mm	KH-LF
V-bolt Kit for KH-LF.	KH-LFV
Damper crank arm Slot width 8.2 mm, for Ø1.05"	KH12
Damper crank arm Slot width 6.2 mm, clamping range Ø10...18 mm	KH6
Damper crank arm Slot width 8.2 mm, clamping range Ø10...18 mm	KH8
Anti-rotation bracket LF.	LF-P
Push rod for KG10A ball joint (36" L, 3/8" diameter).	SH10
Push rod for KG6 & KG8 ball joints (36" L, 5/16" diameter).	SH8
Wrench 8 mm and 10 mm	TOOL-06
Angle of rotation limiter, with end stop	ZDB-LF
Form fit adapter 8x8 mm	ZF8-LF
Mounting Bracket: ZS-260 Right Angle	ZG-109
Linkage kit	ZG-110
Mounting bracket for LF..	ZG-112
Damper clip for damper blade, 3.5" width.	ZG-DC1
Damper clip for damper blade, 6" width.	ZG-DC2
LF crankarm adaptor kit (includes ZG-112).	ZG-LF112
LF crankarm adaptor kit (T bracket included).	ZG-LF2
Shaft extension for 3/8" diameter shafts (4" L).	ZG-LMSA-1
Shaft extension for 1/2" diameter shafts (5" L).	ZG-LMSA-1/2-5
Weather shield 13x8x6" [330x203x152 mm] (LxWxH)	ZS-100
Base Plate, for ZS-100	ZS-101
Weather shield 16x8-3/8x4" [406x213x102 mm] (LxWxH)	ZS-150
Explosion Proof Housing 16x10x6.435" [406x254x164 mm] (LxWxH), UL and CSA, Class I, Zone 1&2, Groups B, C, D, (NEMA 7), Class III, Hazardous (classified) Locations	ZS-260
Weather shield 17-1/4x8-3/4x5-1/2" [438x222x140 mm] (LxWxH), NEMA 4X, with mounting brackets	ZS-300
Weather shield 17-1/4x8-3/4x5-1/2" [438x222x140 mm] (LxWxH), NEMA 4X, with mounting brackets	ZS-300-5

	Shaft extension 1/2"	ZS-300-C1
	Shaft extension 3/4"	ZS-300-C2
	Shaft extension 1"	ZS-300-C3
Service tools	**Description**	**Type**
	Connection cable 10 ft [3 m], A: RJ11 6/4 ZTH EU, B: 3-pin Weidmüller and supply connection	ZK4-GEN
	Service Tool, with ZIP-USB function, for parametrisable and communicative Belimo actuators, VAV controller and HVAC performance devices	ZTH US

Electrical installation

Warning! Live Electrical Components!
During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.

Meets cULus requirements without the need of an electrical ground connection.

Apply only AC line voltage or only UL-Class 2 voltage to the terminals of auxiliary switches. Mixed or combined operation of line voltage/safety extra low voltage is not allowed.

A Actuators with appliance cables are numbered.

1 Provide overload protection and disconnect as required.

3 Actuators may also be powered by 24 VDC.

5 Only connect common to negative (-) leg of control circuits.

7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.

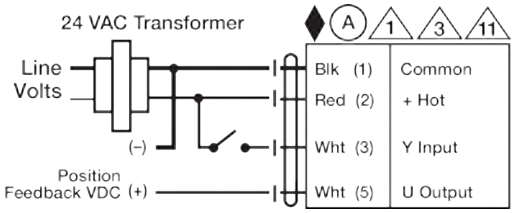
8 Control signal may be pulsed from either the Hot (Source) or Common (Sink) 24 V line.

10 For triac sink the Common connection from the actuator must be connected to the Hot connection of the controller. Position feedback cannot be used with a triac sink controller; the actuator internal common reference is not compatible.

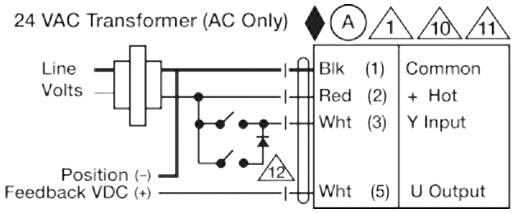
11 Actuators may be connected in parallel if not mechanically linked. Power consumption and input impedance must be observed.

12 IN4004 or IN4007 diode. (IN4007 supplied, Belimo part number 40155).

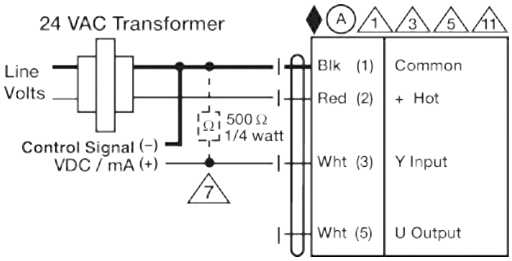
44 One built-in auxiliary switch (1x SPDT), for end position indication, interlock control, fan startup, etc.



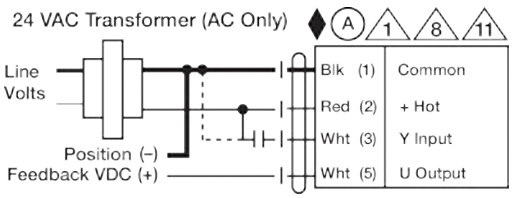
On/Off



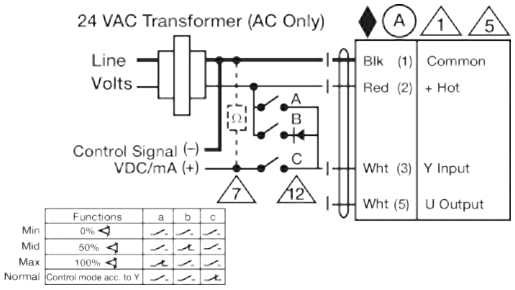
Floating Point



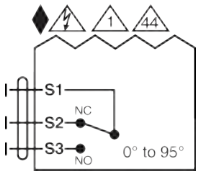
VDC/mA Control



PWM Control



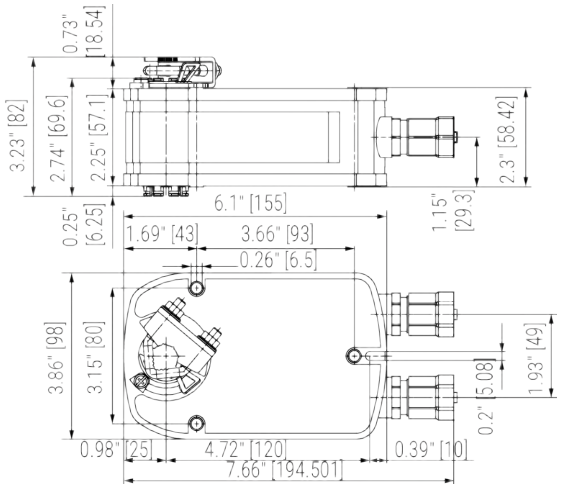
Override Control



Auxiliary Switches

Dimensions

Dimensional drawings



BELIMO

Stainless Steel Ball and Stem

Technical data sheet B223

5-year warranty

Technical data

Functional data	Valve Size	1" [25]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	0...250°F [-18...120°C]
	Body Pressure Rating	600 psi
	Close-off pressure Δps	200 psi
	Flow characteristic	equal percentage
	Servicing	maintenance-free
	Flow Pattern	2-way
	Leakage rate	0% for A – AB
	Controllable flow range	75°
	Cv	10
	Body pressure rating note	600 psi
	Cv Flow Rating	A-port: as stated in chart B-port: 70% of A – AB Cv
Materials	Valve body	Nickel-plated brass body
	Stem seal	EPDM (lubricated)
	Seat	PTFE
	Pipe connection	NPT female ends
	O-ring	EPDM (lubricated)
	Ball	stainless steel
Suitable actuators	Non-Spring	LRB(X) NR

Safety notes

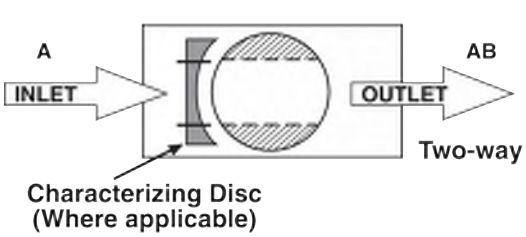
- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov

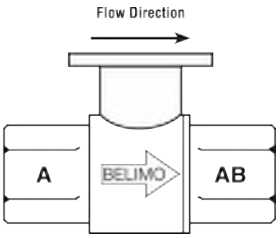
Product features

Application

This valve is typically used in air handling units on heating or cooling coils, and fan coil unit heating or cooling coils. Some other common applications include Unit Ventilators, VAV box re-heat coils and bypass loops. This valve is suitable for use in a hydronic system with variable flow.

Flow/Mounting details

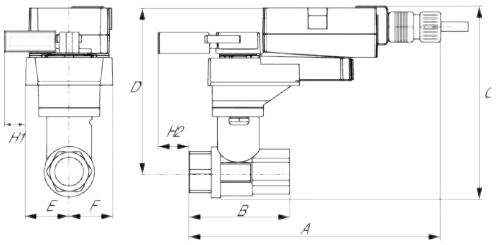




Dimensions

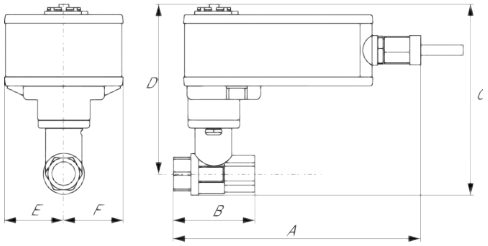
Dimensional drawings

LRB, LRX



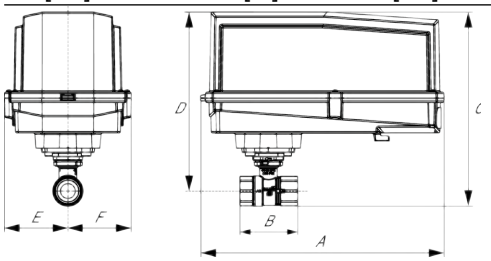
A	B	C	D	E	F	H1	H2
9.4" [239]	3.1" [78]	7.2" [184]	6.3" [161]	1.3" [33]	1.3" [33]	1.2" [30]	0.9" [23]

LF



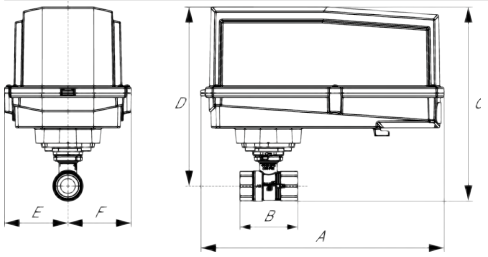
A	B	C	D	E	F
8.1" [206]	3.1" [78]	6.5" [165]	5.6" [142]	1.8" [46]	1.8" [46]

ARB N4, ARX N4, NRB N4, NRX N4



A	B	C	D	E	F
11.4" [289]	3.1" [78]	7.8" [199]	7.1" [181]	3.1" [80]	3.1" [80]

ARB N4, ARX N4, NRB N4, NRX N4



A	B	C	D	E	F
11.4" [289]	3.1" [78]	7.8" [199]	7.1" [181]	3.1" [80]	3.1" [80]

BELIMO

Modulating, Spring Return, 24 V, Multi-Function Technology®

Proportional, Spring Return, Multi-Function Technology®, Torque min. 35 in-lb, Control 2 to 10 VDC (DEFAULT), Feedback 2 to 10 VDC (DEFAULT)

Technical data sheet LF24-MFT-S US

5-year warranty

MFT

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	2.5 W
	Power consumption in rest position	1 W
	Transformer sizing	5 VA (class 2 power source)
	Auxiliary switch	1 x SPDT, 3 A resistive (0.5 A inductive) @ AC 250 V, adjustable 0...95°
	Switching capacity auxiliary switch	3 A resistive (0.5 A inductive) @ AC 250 V
	Electrical Connection	(2) 18 GA appliance cables with 1/2" conduit connectors, 3 ft [1 m],
	Overload Protection	electronic throughout 0...95° rotation
	Electrical Protection	actuators are double insulated
Functional data	Torque motor	35 in-lb [4 Nm]
	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for 2...10 V (0.1 mA), 500 Ω for 4...20 mA, 1500 Ω for PWM, On/Off and Floating point
	Operating range Y variable	Start point 0.5...30 V End point 2.5...32 V
	Options positioning signal	variable (VDC, PWM, on/off, floating point)
	Position feedback U	2...10 V
	Position feedback U note	Max. 0.5 mA
	Position feedback U variable	VDC variable
	Direction of motion motor	selectable with switch 0/1
	Direction of motion fail-safe	reversible with cw/ccw mounting
	Angle of rotation	Max. 95°, adjustable with mechanical stop
	Angle of rotation note	adjustable with mechanical stop
	Running Time (Motor)	default 150 s, variable 75...300 s
	Running time motor variable	75...300 s
	Running time fail-safe	<25 s @ -4...122°F [-20...50°C], <60 s @ -22°F [-30°C]
	Angle of rotation adaptation	off (default)
	Override control	MIN (minimum position) = 0% MID (intermediate position) = 50% MAX (maximum position) = 100%
	Noise level, motor	30 dB(A)
	Noise level, fail-safe	62 dB(A)
	Shaft Diameter	3/8...1/2" round, centers on 1/2"
	Position indication	Mechanical
Safety data	Degree of protection IEC/EN	IP54

	Degree of protection NEMA/UL	NEMA 2 UL Enclosure Type 2
	Agency Listing	cULus acc. To UL 873 and CAN/CSA C22.2 No. 24-93
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	3.3 lb [1.5 kg]
Materials	Housing material	galvanized steel

Product features

Default/Configuration

Default parameters for 2 to 10 VDC applications of the LF..-MFT actuator are assigned during manufacturing. If required, custom versions of the actuator can be ordered. The parameters are variable and can be changed by three means: Factory pre-set or custom configuration, set by the customer using PC-Tool software or the handheld ZTH US.

Application

For fail-safe, modulating control of dampers in HVAC systems. Actuator sizing should be done in accordance with the damper manufacturer's specifications. A feedback signal is provided for position indication.

Operation

The LF24-MFT US actuator provides 95° of rotation and is provided with a graduated position indicator showing 0° to 95°. The actuator will synchronize the 0° mechanical stop or the damper or valves mechanical stop and use this point for its zero position during normal control operations. The actuator uses a brushless DC motor which is controlled by an Application Specific Integrated Circuit (ASIC) and a microprocessor. The microprocessor provides the intelligence to the ASIC to provide a constant rotation rate and to know the actuator's exact position. The ASIC monitors and controls the brushless DC motor's rotation and provides a Digital Rotation Sensing (DRS) function to prevent damage to the actuator in a stall condition. The position feedback signal is generated without the need for mechanical feedback potentiometers using DRS. The actuator may be stalled anywhere in its normal rotation without the need of mechanical end switches. The LF24-MFT US is mounted directly to control shafts up to 3/4" diameter (K6-1 clamp) and anti-rotation bracket. A crank arm and several mounting brackets are available for damper applications where the actuator cannot be direct coupled to the damper shaft. The spring return system provides minimum specified torque to the application during a power interruption. The LF24-MFT US actuator is shipped in the zero position, compression against seats or gaskets for tight shut-off is accomplished manually.

Typical specification

Spring return control damper actuators shall be direct coupled type which require no crank arm and linkage and be capable of direct mounting to a shaft up to a 3/4" diameter and center on a 1/2" shaft (default). Actuator shall deliver a minimum output torque of 35 in-lbs. The actuator must provide modulating damper control in response to a 2 to 10 VDC or, with the addition of a 500Ω resistor, a 4 to 20 mA control input from an electronic controller or positioner. The actuators must be designed so that they may be used for either clockwise or counter clockwise fail-safe operation. Actuators shall use a brushless DC motor controlled by a microprocessor and be protected from overload at all angles of rotation. Run time shall be constant, and independent of torque. A 2 to 10 VDC feedback signal shall be provided for position feedback. Actuators with auxiliary switches must be constructed to meet the requirements for Double Insulation so an electrical ground is not required to meet agency listings. Actuators shall be cULus listed and have a 5 year warranty, and be manufactured under ISO 9001 International Quality Control Standards. Actuators shall be as manufactured by Belimo.

Factory settings

Default parameters for 2 to 10 VDC applications of the LF..-MFT actuator are assigned during manufacturing. If required, custom versions of the actuator can be ordered. The parameters are variable and can be changed by three means: Factory pre-set or custom configuration, set by the customer using PC-Tool software or the handheld ZTH US.

Accessories

Gateways

Description	Type
Gateway MP to BACnet MS/TP	UK24BAC
Gateway MP to LonWorks	UK24LON
Gateway MP to Modbus RTU	UK24MOD

Electrical accessories

Description	Type
DC Voltage Input Rescaling Module	IRM-100
Belimo PC-Tool, Software for adjustments and diagnostics	MFT-P
Auxiliary switch, mercury-free	P475
Auxiliary switch, mercury-free	P475-1
Signal Siumlator, Power supply AC 230 V	PS-100
Convert Pulse Width Modulated Signal to a 2...10 V Signal for Belimo Proportional Actuators	PTA-250
Positioner for wall mounting	SGA24
Positioner for front-panel mounting	SGF24
Gateway MP to BACnet MS/TP	UK24BAC
Gateway MP to LonWorks	UK24LON
Gateway MP to Modbus RTU	UK24MOD
Conduit box converter	ZG-CBLS
Resistor, 500 Ω, 1/4" wire resistor with 6" pigtail wires	ZG-R01
Resistor Kit, 50% voltage divider	ZG-R02
Mounting plate for SGF.	ZG-SGF
Transformer, AC 120 V to AC 24 V, 40 VA	ZG-X40
Connection cable 16 ft [5 m], A: RJ11 6/4 ZTH EU, B: free wire end for connection to MP/PP terminal	ZK2-GEN
Service Tool, with ZIP-USB function, for parametrisable and communicative Belimo actuators, VAV controller and HVAC performance devices	ZTH US

Mechanical accessories

Description	Type
Shaft extension 170 mm Ø10 mm for damper shaft Ø 6...16 mm	AV6-20
End stop indicator	IND-LF
Shaft clamp for LF..	K6 US
Shaft clamp reversible, clamping range Ø16...20 mm	K6-1
Ball joint suitable for damper crank arm KH8 / KH10	KG10A
Ball joint suitable for damper crank arm KH8	KG6
Ball joint suitable for damper crank arm KH8	KG8
Actuator arm, clamping range Ø8...16 mm, Slot width 8.2 mm	KH-LF
V-bolt Kit for KH-LF.	KH-LFV
Damper crank arm Slot width 8.2 mm, for Ø1.05"	KH12
Damper crank arm Slot width 6.2 mm, clamping range Ø10...18 mm	KH6
Damper crank arm Slot width 8.2 mm, clamping range Ø10...18 mm	KH8
Anti-rotation bracket LF.	LF-P
Push rod for KG10A ball joint (36" L, 3/8" diameter).	SH10
Push rod for KG6 & KG8 ball joints (36" L, 5/16" diameter).	SH8
Wrench 8 mm and 10 mm	TOOL-06
Angle of rotation limiter, with end stop	ZDB-LF
Form fit adapter 8x8 mm	ZF8-LF
Mounting Bracket: ZS-260 Right Angle	ZG-109
Linkage kit	ZG-110
Mounting bracket for LF..	ZG-112
Damper clip for damper blade, 3.5" width.	ZG-DC1
Damper clip for damper blade, 6" width.	ZG-DC2
LF crankarm adaptor kit (includes ZG-112).	ZG-LF112
LF crankarm adaptor kit (T bracket included).	ZG-LF2
Shaft extension for 3/8" diameter shafts (4" L).	ZG-LMSA-1
Shaft extension for 1/2" diameter shafts (5" L).	ZG-LMSA-1/2-5
Weather shield 13x8x6" [330x203x152 mm] (LxWxH)	ZS-100
Base Plate, for ZS-100	ZS-101
Weather shield 16x8-3/8x4" [406x213x102 mm] (LxWxH)	ZS-150
Explosion Proof Housing 16x10x6.435" [406x254x164 mm] (LxWxH), UL and CSA, Class I, Zone 1&2, Groups B, C, D, (NEMA 7), Class III, Hazardous (classified) Locations	ZS-260
Weather shield 17-1/4x8-3/4x5-1/2" [438x222x140 mm] (LxWxH), NEMA 4X, with mounting brackets	ZS-300
Weather shield 17-1/4x8-3/4x5-1/2" [438x222x140 mm] (LxWxH), NEMA 4X, with mounting brackets	ZS-300-5

	Shaft extension 1/2"	ZS-300-C1
	Shaft extension 3/4"	ZS-300-C2
	Shaft extension 1"	ZS-300-C3
Service tools	**Description**	**Type**
	Connection cable 10 ft [3 m], A: RJ11 6/4 ZTH EU, B: 3-pin Weidmüller and supply connection	ZK4-GEN
	Service Tool, with ZIP-USB function, for parametrisable and communicative Belimo actuators, VAV controller and HVAC performance devices	ZTH US

Electrical installation

Warning! Live Electrical Components!
During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.

Meets cULus requirements without the need of an electrical ground connection.

Apply only AC line voltage or only UL-Class 2 voltage to the terminals of auxiliary switches. Mixed or combined operation of line voltage/safety extra low voltage is not allowed.

A Actuators with appliance cables are numbered.

1 Provide overload protection and disconnect as required.

3 Actuators may also be powered by 24 VDC.

5 Only connect common to negative (-) leg of control circuits.

7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.

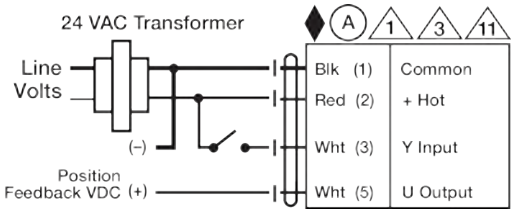
8 Control signal may be pulsed from either the Hot (Source) or Common (Sink) 24 V line.

10 For triac sink the Common connection from the actuator must be connected to the Hot connection of the controller. Position feedback cannot be used with a triac sink controller; the actuator internal common reference is not compatible.

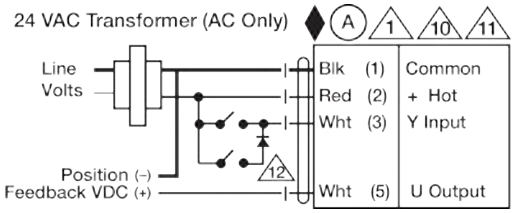
11 Actuators may be connected in parallel if not mechanically linked. Power consumption and input impedance must be observed.

12 IN4004 or IN4007 diode. (IN4007 supplied, Belimo part number 40155).

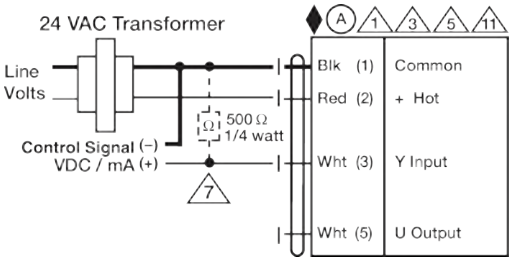
44 One built-in auxiliary switch (1x SPDT), for end position indication, interlock control, fan startup, etc.



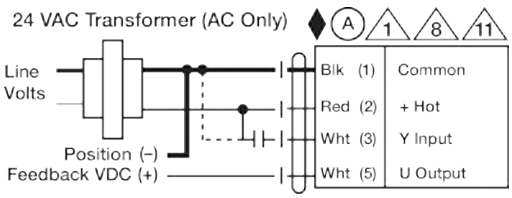
On/Off



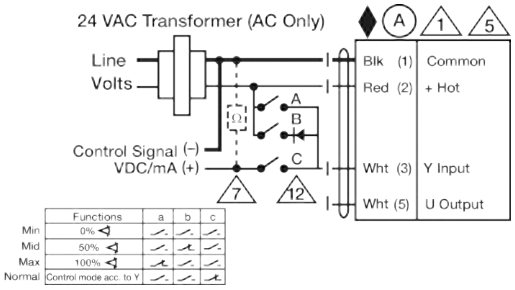
Floating Point



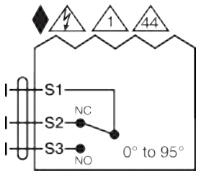
VDC/mA Control



PWM Control



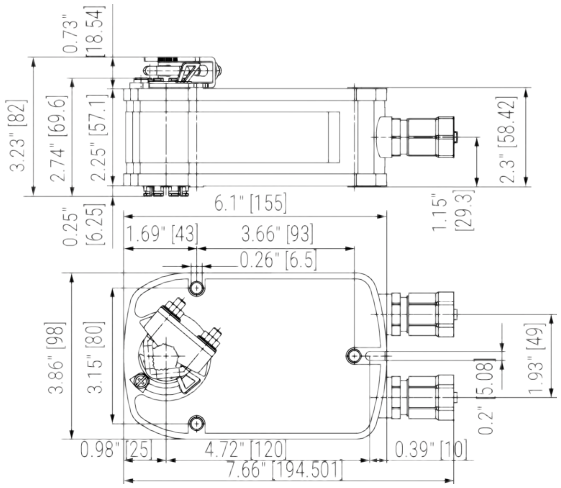
Override Control



Auxiliary Switches

Dimensions

Dimensional drawings



BELIMO

Stainless Steel Ball and Stem

Technical data sheet B230

5-year warranty

Technical data

Functional data	Valve Size	1.25" [32]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	0...250°F [-18...120°C]
	Body Pressure Rating	600 psi
	Close-off pressure Δps	200 psi
	Flow characteristic	equal percentage
	Servicing	maintenance-free
	Flow Pattern	2-way
	Leakage rate	0% for A – AB
	Controllable flow range	75°
	Cv	19
	Body pressure rating note	600 psi
	No Characterized Disc	TRUE
Materials	Valve body	Nickel-plated brass body
	Stem seal	EPDM (lubricated)
	Seat	PTFE
	Pipe connection	NPT female ends
	O-ring	EPDM (lubricated)
	Ball	stainless steel
Suitable actuators	Non-Spring	LRB(X) NR

Safety notes

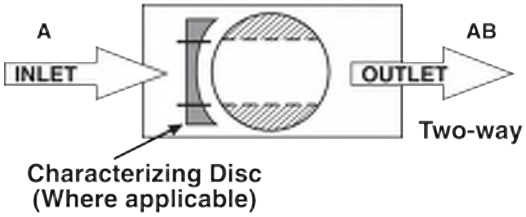
- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov

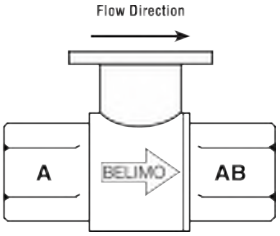
Product features

Application

This valve is typically used in air handling units on heating or cooling coils, and fan coil unit heating or cooling coils. Some other common applications include Unit Ventilators, VAV box re-heat coils and bypass loops. This valve is suitable for use in a hydronic system with variable flow.

Flow/Mounting details

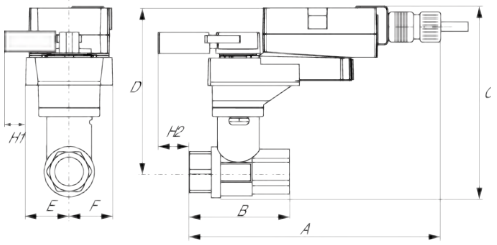




Dimensions

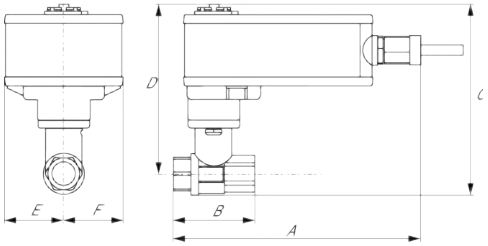
Dimensional drawings

LRB, LRX



A	B	C	D	E	F	H1	H2
9.4" [239]	3.7" [95]	7.2" [184]	6.3" [161]	1.3" [33]	1.3" [33]	1.2" [30]	0.6" [15]

LF



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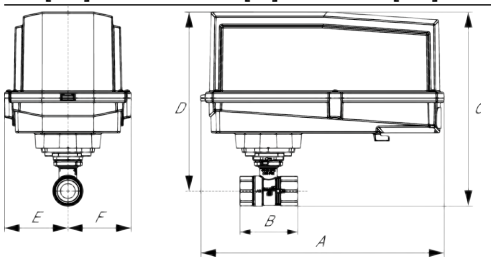
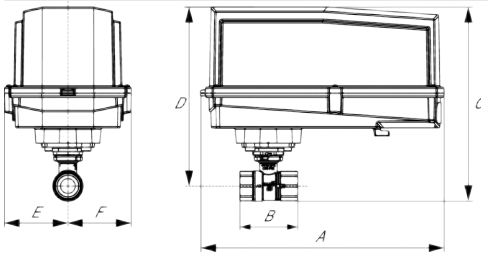
ARB N4, ARX N4, NRB N4, NRX N4



A	B	C	D	E	F
11.4" [289]	3.7" [95]	7.8" [199]	7.1" [181]	3.1" [80]	3.1" [80]

ARB N4, ARX N4, NRB N4, NRX N4



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BELIMO

Modulating, Spring Return, 24 V, Multi-Function Technology®

Proportional, Spring Return, Multi-Function Technology®, Torque min. 35 in-lb, Control 2 to 10 VDC (DEFAULT), Feedback 2 to 10 VDC (DEFAULT)

Technical data sheet LF24-MFT-S US

5-year warranty

MFT

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	2.5 W
	Power consumption in rest position	1 W
	Transformer sizing	5 VA (class 2 power source)
	Auxiliary switch	1 x SPDT, 3 A resistive (0.5 A inductive) @ AC 250 V, adjustable 0...95°
	Switching capacity auxiliary switch	3 A resistive (0.5 A inductive) @ AC 250 V
	Electrical Connection	(2) 18 GA appliance cables with 1/2" conduit connectors, 3 ft [1 m],
	Overload Protection	electronic throughout 0...95° rotation
	Electrical Protection	actuators are double insulated
Functional data	Torque motor	35 in-lb [4 Nm]
	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for 2...10 V (0.1 mA), 500 Ω for 4...20 mA, 1500 Ω for PWM, On/Off and Floating point
	Operating range Y variable	Start point 0.5...30 V End point 2.5...32 V
	Options positioning signal	variable (VDC, PWM, on/off, floating point)
	Position feedback U	2...10 V
	Position feedback U note	Max. 0.5 mA
	Position feedback U variable	VDC variable
	Direction of motion motor	selectable with switch 0/1
	Direction of motion fail-safe	reversible with cw/ccw mounting
	Angle of rotation	Max. 95°, adjustable with mechanical stop
	Angle of rotation note	adjustable with mechanical stop
	Running Time (Motor)	default 150 s, variable 75...300 s
	Running time motor variable	75...300 s
	Running time fail-safe	<25 s @ -4...122°F [-20...50°C], <60 s @ -22°F [-30°C]
	Angle of rotation adaptation	off (default)
	Override control	MIN (minimum position) = 0% MID (intermediate position) = 50% MAX (maximum position) = 100%
	Noise level, motor	30 dB(A)
	Noise level, fail-safe	62 dB(A)
	Shaft Diameter	3/8...1/2" round, centers on 1/2"
	Position indication	Mechanical
Safety data	Degree of protection IEC/EN	IP54

	Degree of protection NEMA/UL	NEMA 2 UL Enclosure Type 2
	Agency Listing	cULus acc. To UL 873 and CAN/CSA C22.2 No. 24-93
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	3.3 lb [1.5 kg]
Materials	Housing material	galvanized steel

Product features

Default/Configuration

Default parameters for 2 to 10 VDC applications of the LF..-MFT actuator are assigned during manufacturing. If required, custom versions of the actuator can be ordered. The parameters are variable and can be changed by three means: Factory pre-set or custom configuration, set by the customer using PC-Tool software or the handheld ZTH US.

Application

For fail-safe, modulating control of dampers in HVAC systems. Actuator sizing should be done in accordance with the damper manufacturer's specifications. A feedback signal is provided for position indication.

Operation

The LF24-MFT US actuator provides 95° of rotation and is provided with a graduated position indicator showing 0° to 95°. The actuator will synchronize the 0° mechanical stop or the damper or valves mechanical stop and use this point for its zero position during normal control operations. The actuator uses a brushless DC motor which is controlled by an Application Specific Integrated Circuit (ASIC) and a microprocessor. The microprocessor provides the intelligence to the ASIC to provide a constant rotation rate and to know the actuator's exact position. The ASIC monitors and controls the brushless DC motor's rotation and provides a Digital Rotation Sensing (DRS) function to prevent damage to the actuator in a stall condition. The position feedback signal is generated without the need for mechanical feedback potentiometers using DRS. The actuator may be stalled anywhere in its normal rotation without the need of mechanical end switches. The LF24-MFT US is mounted directly to control shafts up to 3/4" diameter (K6-1 clamp) and anti-rotation bracket. A crank arm and several mounting brackets are available for damper applications where the actuator cannot be direct coupled to the damper shaft. The spring return system provides minimum specified torque to the application during a power interruption. The LF24-MFT US actuator is shipped in the zero position, compression against seats or gaskets for tight shut-off is accomplished manually.

Typical specification

Spring return control damper actuators shall be direct coupled type which require no crank arm and linkage and be capable of direct mounting to a shaft up to a 3/4" diameter and center on a 1/2" shaft (default). Actuator shall deliver a minimum output torque of 35 in-lbs. The actuator must provide modulating damper control in response to a 2 to 10 VDC or, with the addition of a 500Ω resistor, a 4 to 20 mA control input from an electronic controller or positioner. The actuators must be designed so that they may be used for either clockwise or counter clockwise fail-safe operation. Actuators shall use a brushless DC motor controlled by a microprocessor and be protected from overload at all angles of rotation. Run time shall be constant, and independent of torque. A 2 to 10 VDC feedback signal shall be provided for position feedback. Actuators with auxiliary switches must be constructed to meet the requirements for Double Insulation so an electrical ground is not required to meet agency listings. Actuators shall be cULus listed and have a 5 year warranty, and be manufactured under ISO 9001 International Quality Control Standards. Actuators shall be as manufactured by Belimo.

Factory settings

Default parameters for 2 to 10 VDC applications of the LF..-MFT actuator are assigned during manufacturing. If required, custom versions of the actuator can be ordered. The parameters are variable and can be changed by three means: Factory pre-set or custom configuration, set by the customer using PC-Tool software or the handheld ZTH US.

Accessories

Gateways

Description	Type
Gateway MP to BACnet MS/TP	UK24BAC
Gateway MP to LonWorks	UK24LON
Gateway MP to Modbus RTU	UK24MOD

Electrical accessories

Description	Type
DC Voltage Input Rescaling Module	IRM-100
Belimo PC-Tool, Software for adjustments and diagnostics	MFT-P
Auxiliary switch, mercury-free	P475
Auxiliary switch, mercury-free	P475-1
Signal Siumlator, Power supply AC 230 V	PS-100
Convert Pulse Width Modulated Signal to a 2...10 V Signal for Belimo Proportional Actuators	PTA-250
Positioner for wall mounting	SGA24
Positioner for front-panel mounting	SGF24
Gateway MP to BACnet MS/TP	UK24BAC
Gateway MP to LonWorks	UK24LON
Gateway MP to Modbus RTU	UK24MOD
Conduit box converter	ZG-CBLS
Resistor, 500 Ω, 1/4" wire resistor with 6" pigtail wires	ZG-R01
Resistor Kit, 50% voltage divider	ZG-R02
Mounting plate for SGF.	ZG-SGF
Transformer, AC 120 V to AC 24 V, 40 VA	ZG-X40
Connection cable 16 ft [5 m], A: RJ11 6/4 ZTH EU, B: free wire end for connection to MP/PP terminal	ZK2-GEN
Service Tool, with ZIP-USB function, for parametrisable and communicative Belimo actuators, VAV controller and HVAC performance devices	ZTH US

Mechanical accessories

Description	Type
Shaft extension 170 mm Ø10 mm for damper shaft Ø 6...16 mm	AV6-20
End stop indicator	IND-LF
Shaft clamp for LF..	K6 US
Shaft clamp reversible, clamping range Ø16...20 mm	K6-1
Ball joint suitable for damper crank arm KH8 / KH10	KG10A
Ball joint suitable for damper crank arm KH8	KG6
Ball joint suitable for damper crank arm KH8	KG8
Actuator arm, clamping range Ø8...16 mm, Slot width 8.2 mm	KH-LF
V-bolt Kit for KH-LF.	KH-LFV
Damper crank arm Slot width 8.2 mm, for Ø1.05"	KH12
Damper crank arm Slot width 6.2 mm, clamping range Ø10...18 mm	KH6
Damper crank arm Slot width 8.2 mm, clamping range Ø10...18 mm	KH8
Anti-rotation bracket LF.	LF-P
Push rod for KG10A ball joint (36" L, 3/8" diameter).	SH10
Push rod for KG6 & KG8 ball joints (36" L, 5/16" diameter).	SH8
Wrench 8 mm and 10 mm	TOOL-06
Angle of rotation limiter, with end stop	ZDB-LF
Form fit adapter 8x8 mm	ZF8-LF
Mounting Bracket: ZS-260 Right Angle	ZG-109
Linkage kit	ZG-110
Mounting bracket for LF..	ZG-112
Damper clip for damper blade, 3.5" width.	ZG-DC1
Damper clip for damper blade, 6" width.	ZG-DC2
LF crankarm adaptor kit (includes ZG-112).	ZG-LF112
LF crankarm adaptor kit (T bracket included).	ZG-LF2
Shaft extension for 3/8" diameter shafts (4" L).	ZG-LMSA-1
Shaft extension for 1/2" diameter shafts (5" L).	ZG-LMSA-1/2-5
Weather shield 13x8x6" [330x203x152 mm] (LxWxH)	ZS-100
Base Plate, for ZS-100	ZS-101
Weather shield 16x8-3/8x4" [406x213x102 mm] (LxWxH)	ZS-150
Explosion Proof Housing 16x10x6.435" [406x254x164 mm] (LxWxH), UL and CSA, Class I, Zone 1&2, Groups B, C, D, (NEMA 7), Class III, Hazardous (classified) Locations	ZS-260
Weather shield 17-1/4x8-3/4x5-1/2" [438x222x140 mm] (LxWxH), NEMA 4X, with mounting brackets	ZS-300
Weather shield 17-1/4x8-3/4x5-1/2" [438x222x140 mm] (LxWxH), NEMA 4X, with mounting brackets	ZS-300-5

	Shaft extension 1/2"	ZS-300-C1
	Shaft extension 3/4"	ZS-300-C2
	Shaft extension 1"	ZS-300-C3
Service tools	**Description**	**Type**
	Connection cable 10 ft [3 m], A: RJ11 6/4 ZTH EU, B: 3-pin Weidmüller and supply connection	ZK4-GEN
	Service Tool, with ZIP-USB function, for parametrisable and communicative Belimo actuators, VAV controller and HVAC performance devices	ZTH US

Electrical installation

Warning! Live Electrical Components!
During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.

Meets cULus requirements without the need of an electrical ground connection.

Apply only AC line voltage or only UL-Class 2 voltage to the terminals of auxiliary switches. Mixed or combined operation of line voltage/safety extra low voltage is not allowed.

A Actuators with appliance cables are numbered.

1 Provide overload protection and disconnect as required.

3 Actuators may also be powered by 24 VDC.

5 Only connect common to negative (-) leg of control circuits.

7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.

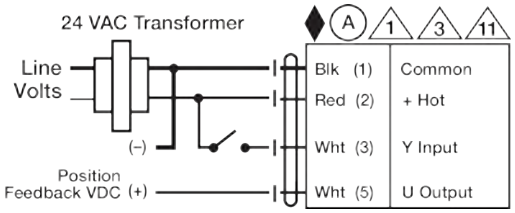
8 Control signal may be pulsed from either the Hot (Source) or Common (Sink) 24 V line.

10 For triac sink the Common connection from the actuator must be connected to the Hot connection of the controller. Position feedback cannot be used with a triac sink controller; the actuator internal common reference is not compatible.

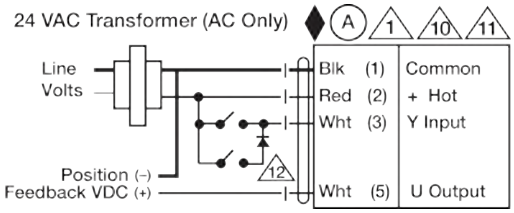
11 Actuators may be connected in parallel if not mechanically linked. Power consumption and input impedance must be observed.

12 IN4004 or IN4007 diode. (IN4007 supplied, Belimo part number 40155).

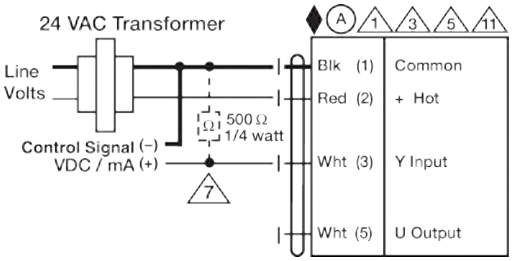
44 One built-in auxiliary switch (1x SPDT), for end position indication, interlock control, fan startup, etc.



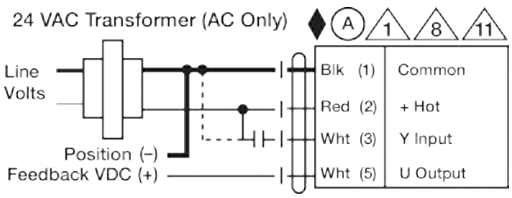
On/Off



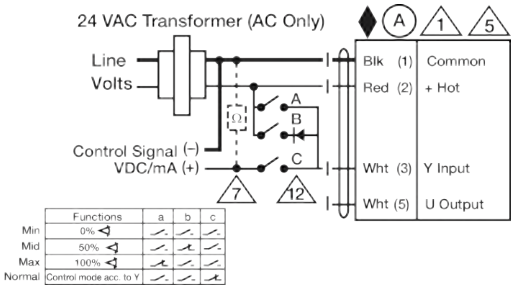
Floating Point



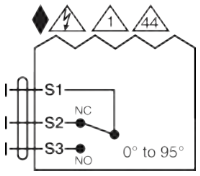
VDC/mA Control



PWM Control



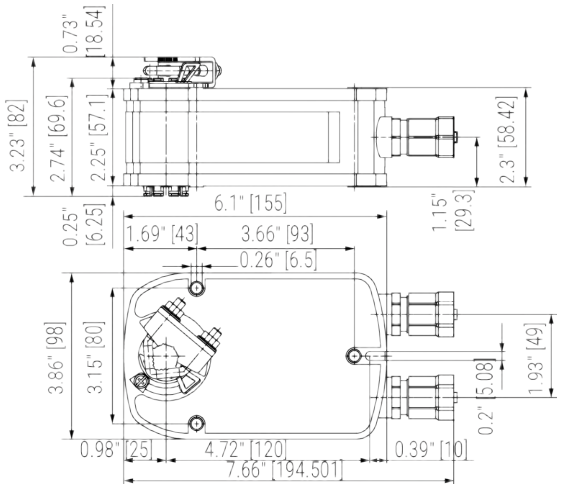
Override Control



Auxiliary Switches

Dimensions

Dimensional drawings



BELIMO

Stainless Steel Ball and Stem

Technical data sheet B230

5-year warranty

Technical data

Functional data	Valve Size	1.25" [32]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	0...250°F [-18...120°C]
	Body Pressure Rating	600 psi
	Close-off pressure Δps	200 psi
	Flow characteristic	equal percentage
	Servicing	maintenance-free
	Flow Pattern	2-way
	Leakage rate	0% for A – AB
	Controllable flow range	75°
	Cv	19
	Body pressure rating note	600 psi
	No Characterized Disc	TRUE
Materials	Valve body	Nickel-plated brass body
	Stem seal	EPDM (lubricated)
	Seat	PTFE
	Pipe connection	NPT female ends
	O-ring	EPDM (lubricated)
	Ball	stainless steel
Suitable actuators	Non-Spring	LRB(X) NR

Safety notes

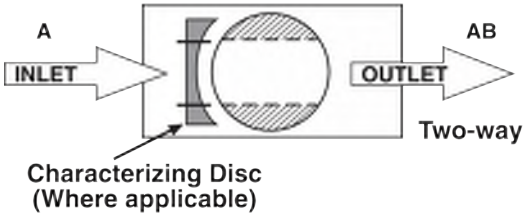
- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov

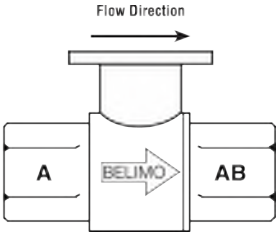
Product features

Application

This valve is typically used in air handling units on heating or cooling coils, and fan coil unit heating or cooling coils. Some other common applications include Unit Ventilators, VAV box re-heat coils and bypass loops. This valve is suitable for use in a hydronic system with variable flow.

Flow/Mounting details

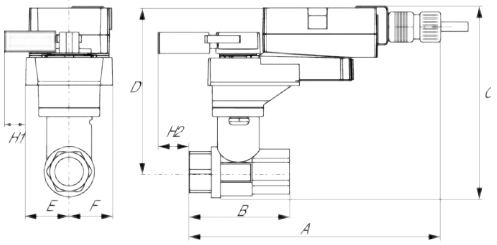




Dimensions

Dimensional drawings

LRB, LRX



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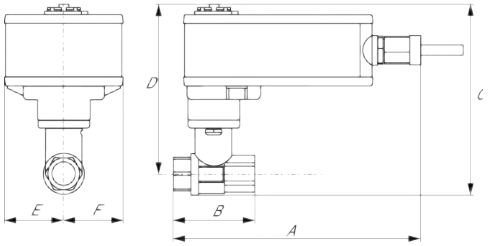
LF



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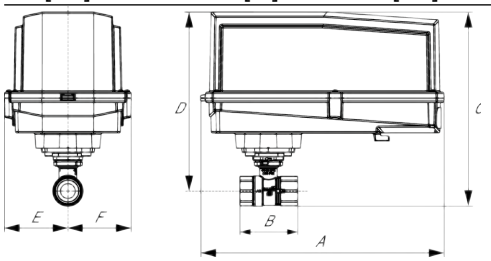

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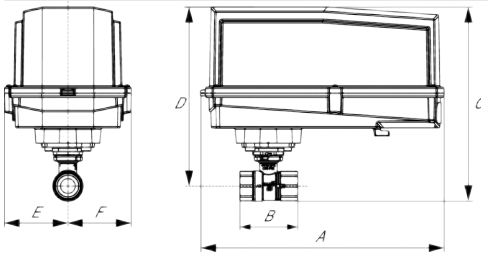
ARB N4, ARX N4, NRB N4, NRX N4



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BELIMO

Modulating, Non-Spring Return, 24 V, Multi-Function Technology®

Technical data sheet LRX24-MFT

5-year warranty

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	2.5 W
	Power consumption in rest position	1.2 W
	Transformer sizing	5 VA (class 2 power source)
	Electrical Connection	18 GA plenum cable with 1/2" conduit connector, degree of protection NEMA 2 / IP54, 3 ft [1 m] 10 ft [3 m] and 16ft [5 m]
	Overload Protection	electronic thoughout 0...90° rotation
Functional data	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for DC 2...10 V (0.1 mA), 500 Ω for 4...20 mA, 1500 Ω for PWM and On/Off
	Operating range Y variable	Start point 0.5...30 V End point 2.5...32 V
	Options positioning signal	variable (VDC, on/off, floating point)
	Position feedback U	2...10 V
	Position feedback U note	Max. 0.5 mA
	Position feedback U variable	VDC variable
	Direction of motion motor	selectable with switch 0/1
	Manual override	external push button
	Angle of rotation	90°
	Angle of rotation note	adjustable with mechanical stop
	Running Time (Motor)	default 150 s, variable 35...150 s
	Running time motor variable	35...150 s
	Noise level, motor	35 dB(A)
	Position indication	Mechanically, pluggable
Safety data	Degree of protection IEC/EN	IP54
	Degree of protection NEMA/UL	NEMA 2 UL Enclosure Type 2
	Agency Listing	cULus acc. to UL60730-1A/-2-14, CAN/CSA E60730-1:02, CE acc. to 2014/30/EU
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	1.5 lb [0.70 kg]

Safety notes

- Cable for ZIP-RS232 US and ZIP-USB-MP US to Belimo gateways.
- Classic GM to GMB(X) retrofit bracket.
- Battery Back Up System for SY(7~10)-110
- 120 to 24 VAC, 40 VA transformer.
- 12VDC 1.2 AH battery (2 required).
- 50% voltage divider kit (resistors with wires).
- PC Tool computer programming interface, serial port.

Accessories

Gateways	Description	Type
	Gateway MP to BACnet MS/TP	UK24BAC
	Gateway MP to LonWorks	UK24LON
	Gateway MP to Modbus RTU	UK24MOD
Service tools	**Description**	**Type**
	Connection cable 10 ft [3 m], A: RJ11 6/4 ZTH EU, B: 3-pin Weidmüller and supply connection	ZK4-GEN
	Service Tool, with ZIP-USB function, for parametrisable and communicative Belimo actuators, VAV controller and HVAC performance devices	ZTH US

Electrical installation

INSTALLATION NOTES

1 Provide overload protection and disconnect as required.

2 Actuators may be connected in parallel. Power consumption and input impedance must be observed.

3 Actuators may also be powered by 24 VDC.

5 Only connect common to negative (-) leg of control circuits.

7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.

8 Control signal may be pulsed from either the Hot (Source) or Common (Sink) 24 V line.

10 For triac sink the Common connection from the actuator must be connected to the Hot connection of the controller. Position feedback cannot be used with a triac sink controller; the actuator internal common reference is not compatible.

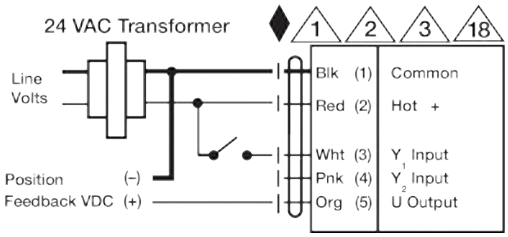
12 IN4004 or IN4007 diode. (IN4007 supplied, Belimo part number 40155).

18 Actuators with plenum cable do not have numbers; use color codes instead.

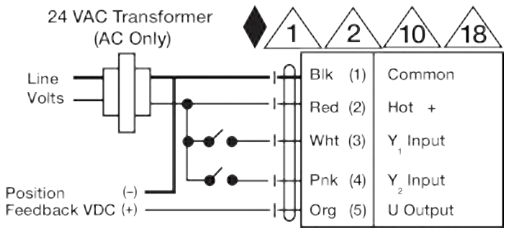
◆ Meets cULus requirements without the need of an electrical ground connection.

! **Warning! Live Electrical Components!**

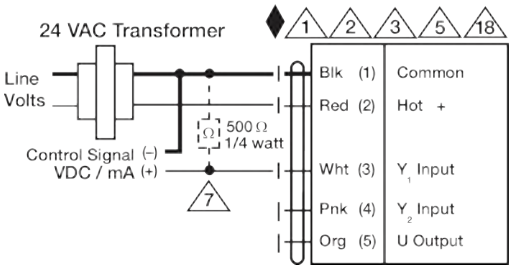
During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.



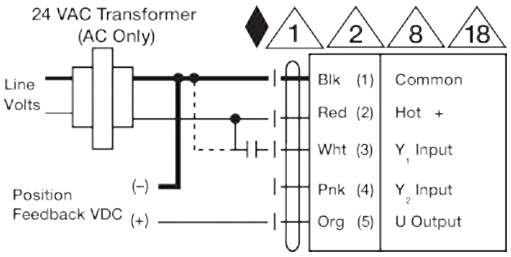
On/Off



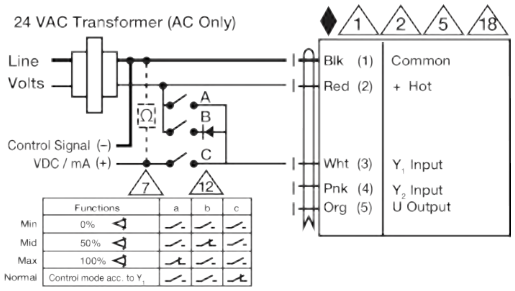
Floating Point



VDC/mA Control



PWM Control



Override Control

BELIMO

Stainless Steel Ball and Stem

Technical data sheet B231

5-year warranty

Technical data

Functional data	Valve Size	1.25" [32]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	0...250°F [-18...120°C]
	Body Pressure Rating	400 psi
	Close-off pressure Δps	200 psi
	Flow characteristic	equal percentage
	Servicing	maintenance-free
	Flow Pattern	2-way
	Leakage rate	0% for A – AB
	Controllable flow range	75°
	Cv	25
	Body pressure rating note	400 psi
	Cv Flow Rating	A-port: as stated in chart B-port: 70% of A – AB Cv
Materials	Valve body	Nickel-plated brass body
	Stem seal	EPDM (lubricated)
	Seat	PTFE
	Pipe connection	NPT female ends
	O-ring	EPDM (lubricated)
	Ball	stainless steel
Suitable actuators	Non-Spring	ARB(X) NRQB(X)

Safety notes

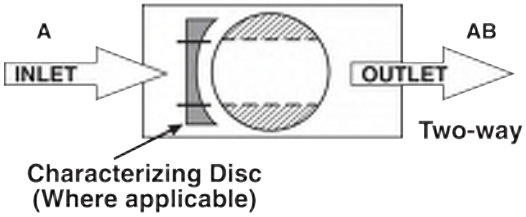
- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov

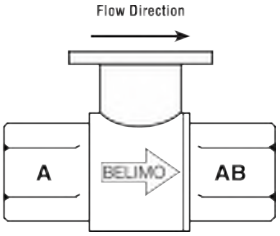
Product features

Application

This valve is typically used in air handling units on heating or cooling coils, and fan coil unit heating or cooling coils. Some other common applications include Unit Ventilators, VAV box re-heat coils and bypass loops. This valve is suitable for use in a hydronic system with variable flow.

Flow/Mounting details

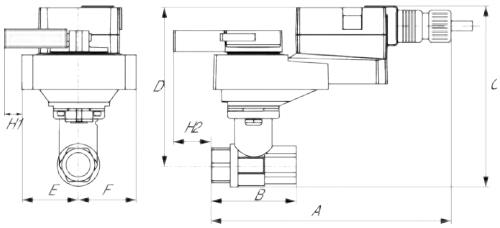




Dimensions

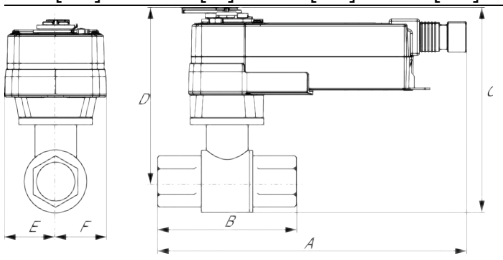
Dimensional drawings

ARB, ARX



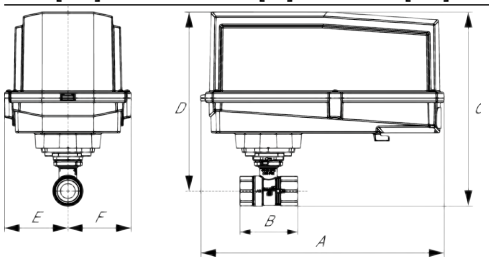
A	B	C	D	E	F	H1	H2
11.0" [280]	3.7" [95]	6.3" [159]	5.9" [150]	1.7" [44]	1.7" [44]	1.2" [30]	0.8" [20]

AFRB, AFRX



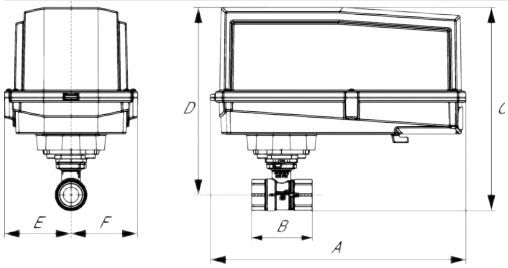
A	B	C	D	E	F
10.5" [267]	3.7" [95]	6.3" [159]	5.3" [134]	2.0" [51]	2.0" [51]

ARB N4, ARX N4, NRB N4, NRX N4



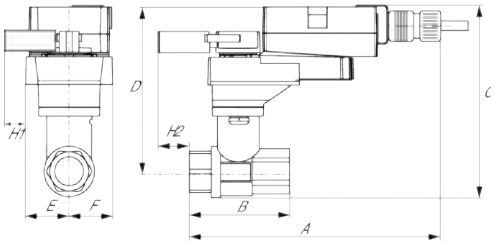
A	B	C	D	E	F
11.4" [289]	3.7" [95]	8.3" [211]	7.3" [185]	3.1" [80]	3.1" [80]

AFRB N4, AFRX N4



A	B	C	D	E	F
13.0" [330]	3.7" [95]	10.3" [262]	8.3" [212]	3.4" [86]	3.4" [86]

NRQB, NRQX



A	B	C	D	E	F
11.0" [280]	3.7" [95]	6.3" [159]	5.9" [150]	1.7" [44]	1.7" [44]

BELIMO

Modulating, Non-Spring Return, 24 V, Multi-Function Technology®

Technical data sheet ARX24-MFT

5-year warranty

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	3.5 W
	Power consumption in rest position	1.3 W
	Transformer sizing	6 VA (class 2 power source)
	Electrical Connection	18 GA plenum cable with 1/2" conduit connector, degree of protection NEMA 2 / IP54, 3 ft [1 m] 10 ft [3 m] and 16ft [5 m]
	Overload Protection	electronic thoughout 0...90° rotation
Functional data	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for 2...10 V (0.1 mA), 500 Ω for 4...20 mA, 1500 Ω for PWM, On/Off and Floating point
	Operating range Y variable	Start point 0.5...30 V End point 2.5...32 V
	Options positioning signal	variable (VDC, on/off, floating point)
	Position feedback U	2...10 V
	Position feedback U note	Max. 0.5 mA
	Position feedback U variable	VDC variable
	Direction of motion motor	selectable with switch 0/1
	Manual override	external push button
	Angle of rotation	90°
	Angle of rotation note	adjustable with mechanical stop
	Running Time (Motor)	default 150 s, variable 90...150 s
	Running time motor variable	90...150 s
	Noise level, motor	45 dB(A)
	Position indication	Mechanically, pluggable
Safety data	Degree of protection IEC/EN	IP54
	Degree of protection NEMA/UL	NEMA 2 UL Enclosure Type 2
	Agency Listing	cULus acc. to UL60730-1A/-2-14, CAN/CSA E60730-1:02, CE acc. to 2014/30/EU
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	2.6 lb [1.2 kg]

Safety notes

- PVC W'Shld for GV w/UGLK (GM)
- Battery Back Up System for SY(7~10)-110
- 120 to 24 VAC, 40 VA transformer.
- Cable for ZTH US to actuators w/o diagnostics socket.
- 50% voltage divider kit (resistors with wires).
- PC Tool computer programming interface, serial port.

Accessories

Gateways	Description	Type
	Gateway MP to BACnet MS/TP	UK24BAC
	Gateway MP to LonWorks	UK24LON
	Gateway MP to Modbus RTU	UK24MOD

Service tools	Description	Type
	Connection cable 10 ft [3 m], A: RJ11 6/4 ZTH EU, B: 3-pin Weidmüller and supply connection	ZK4-GEN
	Service Tool, with ZIP-USB function, for parametrisable and communicative Belimo actuators, VAV controller and HVAC performance devices	ZTH US

Electrical installation

INSTALLATION NOTES

1 Provide overload protection and disconnect as required.

2 Actuators may be connected in parallel. Power consumption and input impedance must be observed.

3 Actuators may also be powered by 24 VDC.

5 Only connect common to negative (-) leg of control circuits.

7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.

8 Control signal may be pulsed from either the Hot (Source) or Common (Sink) 24 V line.

10 For triac sink the Common connection from the actuator must be connected to the Hot connection of the controller. Position feedback cannot be used with a triac sink controller; the actuator internal common reference is not compatible.

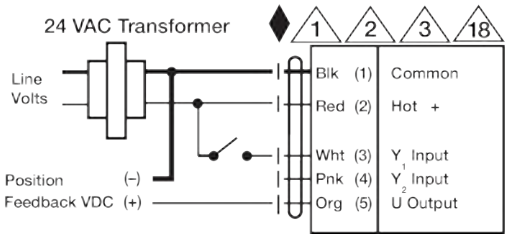
12 IN4004 or IN4007 diode. (IN4007 supplied, Belimo part number 40155).

18 Actuators with plenum cable do not have numbers; use color codes instead.

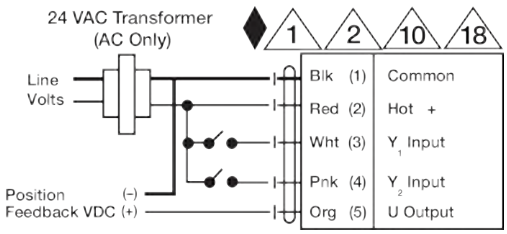
Meets cULus requirements without the need of an electrical ground connection.

Warning! Live Electrical Components!

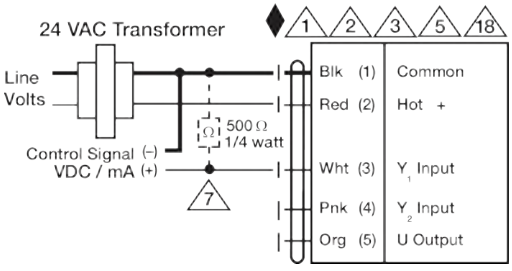
During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.



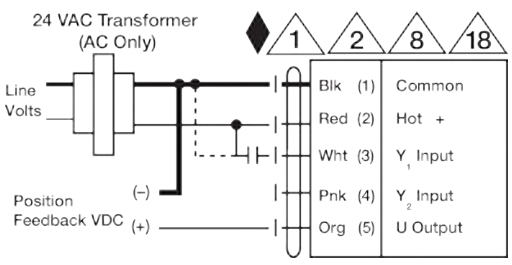
On/Off



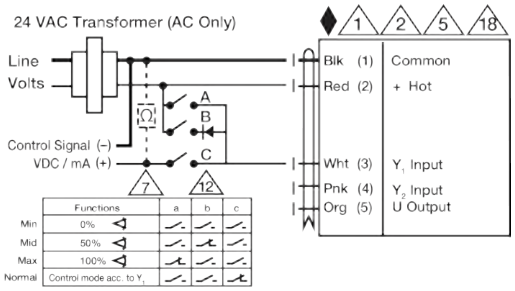
Floating Point



VDC/mA Control



PWM Control



Override Control

BELIMO

Stainless Steel Ball and Stem

Technical data sheet B239

5-year warranty

Technical data

Functional data	Valve Size	1.5" [40]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	0...250°F [-18...120°C]
	Body Pressure Rating	400 psi
	Close-off pressure Δps	200 psi
	Flow characteristic	equal percentage
	Servicing	maintenance-free
	Flow Pattern	2-way
	Leakage rate	0% for A – AB
	Controllable flow range	75°
	Cv	29
	Body pressure rating note	400 psi
	Cv Flow Rating	A-port: as stated in chart B-port: 70% of A – AB Cv
Materials	Valve body	Nickel-plated brass body
	Stem seal	EPDM (lubricated)
	Seat	PTFE
	Pipe connection	NPT female ends
	O-ring	EPDM (lubricated)
	Ball	stainless steel
Suitable actuators	Non-Spring	ARB(X) NRQB(X)

Safety notes

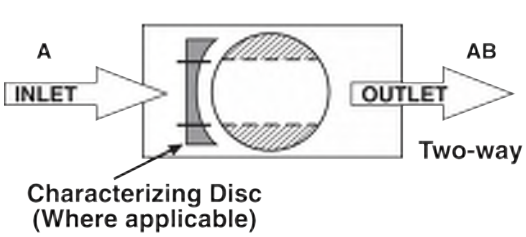
- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov

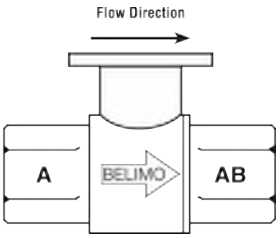
Product features

Application

This valve is typically used in air handling units on heating or cooling coils, and fan coil unit heating or cooling coils. Some other common applications include Unit Ventilators, VAV box re-heat coils and bypass loops. This valve is suitable for use in a hydronic system with variable flow.

Flow/Mounting details

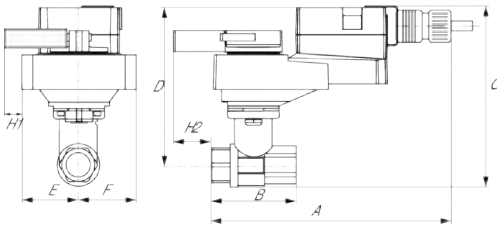




Dimensions

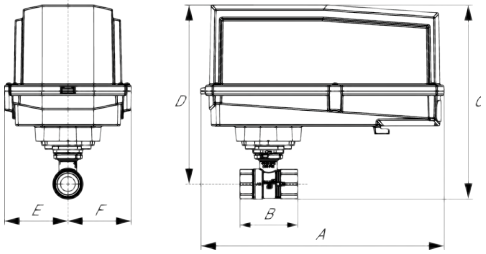
Dimensional drawings

ARB, ARX



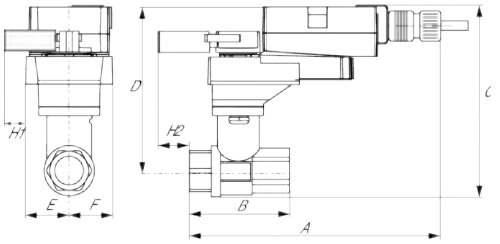
A	B	C	D	E	F	H1	H2
11.0" [280]	3.9" [100]	6.4" [163]	5.3" [134]	1.7" [44]	1.7" [44]	1.2" [30]	0.6" [15]

ARB N4, ARX N4, NRB N4, NRX N4



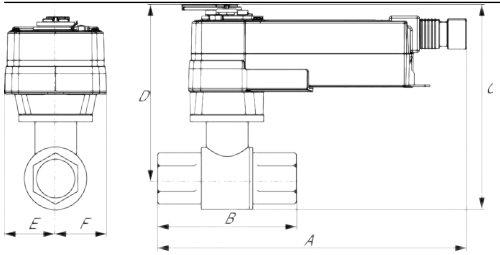
A	B	C	D	E	F
11.4" [289]	3.9" [100]	8.5" [217]	7.3" [185]	3.1" [80]	3.1" [80]

NRQB, NRQX



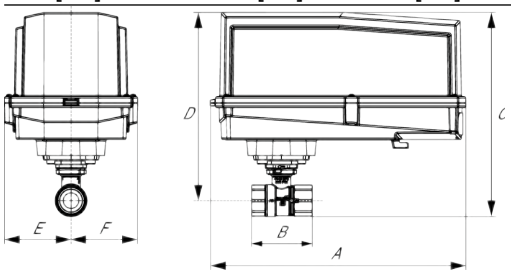
A	B	C	D	E	F	H1	H2
11.0" [280]	3.9" [100]	7.1" [181]	6.0" [152]	1.7" [44]	1.7" [44]	1.4" [34]	0.6" [15]

AFRB, AFRX



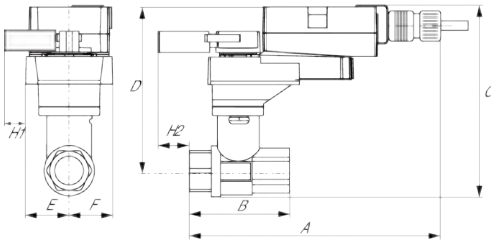
A	B	C	D	E	F
10.8" [275]	3.9" [100]	9.0" [229]	7.8" [198]	2.0" [51]	2.0" [51]

AFRB N4, AFRX N4



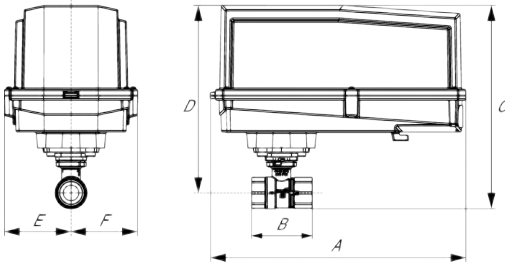
A	B	C	D	E	F
13.0" [330]	3.9" [100]	10.3" [262]	8.5" [216]	3.4" [86]	3.4" [86]

NRQB, NRQX



A	B	C	D	E	F	H1	H2
11.0" [280]	3.9" [100]	7.1" [181]	6.0" [152]	1.7" [44]	1.7" [44]	1.4" [34]	0.6" [15]

AFRB N4, AFRX N4



A	B	C	D	E	F
13.0" [330]	3.9" [100]	10.3" [262]	8.5" [216]	3.4" [86]	3.4" [86]

BELIMO

Modulating, Spring Return, AC 24 V for DC 2...10 V or 4...20 mA Control Signal

Technical data sheet AFRB24-SR

5-year warranty

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	5.5 W
	Power consumption in rest position	3 W
	Transformer sizing	8.5 VA (class 2 power source)
	Electrical Connection	18 GA appliance cable, 3 ft [1 m], with 1/2" conduit connector
	Overload Protection	electronic throughout 0...95° rotation
Functional data	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for 2...10 V (0.1 mA), 500 Ω for 4...20 mA
	Position feedback U	2...10 V
	Position feedback U note	Max. 0.5 mA
	Direction of motion motor	selectable with switch
	Direction of motion fail-safe	reversible with cw/ccw mounting
	Manual override	5 mm hex crank (3/16" Allen), supplied
	Angle of rotation	90°
	Running Time (Motor)	95 s
	Running time fail-safe	<20 s
	Noise level, motor	45 dB(A)
	Noise level, fail-safe	62 dB(A)
	Position indication	Mechanical
Safety data	Degree of protection IEC/EN	IP54
	Degree of protection NEMA/UL	NEMA 2 UL Enclosure Type 2
	Agency Listing	cULus acc. to UL60730-1A/-2-14, CAN/CSA E60730-1:02, CE acc. to 2014/30/EU and 2014/35/EU; Listed to UL 2043 - suitable for use in air plenums per Section 300.22(c) of the NEC and Section 602.2 of the IMC
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	5.4 lb [2.4 kg]

Electrical installation

INSTALLATION NOTES

(A) Actuators with appliance cables are numbered.

1 Provide overload protection and disconnect as required.

3 Actuators may also be powered by 24 VDC.

5 Only connect common to negative (-) leg of control circuits.

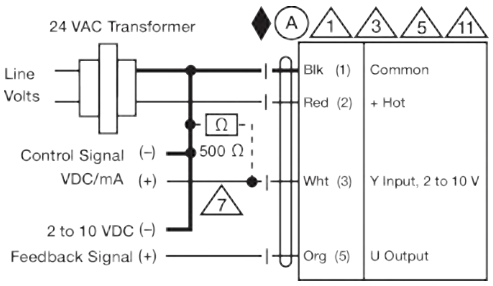
7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.

11 Actuators may be connected in parallel if not mechanically linked. Power consumption and input impedance must be observed.

Meets cULus requirements without the need of an electrical ground connection.

Warning! Live Electrical Components!

During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.



2...10 V / 4...20 mA Control

BELIMO

Stainless Steel Ball and Stem

Technical data sheet B239

5-year warranty

Technical data

Functional data	Valve Size	1.5" [40]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	0...250°F [-18...120°C]
	Body Pressure Rating	400 psi
	Close-off pressure Δps	200 psi
	Flow characteristic	equal percentage
	Servicing	maintenance-free
	Flow Pattern	2-way
	Leakage rate	0% for A – AB
	Controllable flow range	75°
	Cv	29
	Body pressure rating note	400 psi
	Cv Flow Rating	A-port: as stated in chart B-port: 70% of A – AB Cv
Materials	Valve body	Nickel-plated brass body
	Stem seal	EPDM (lubricated)
	Seat	PTFE
	Pipe connection	NPT female ends
	O-ring	EPDM (lubricated)
	Ball	stainless steel
Suitable actuators	Non-Spring	ARB(X) NRQB(X)

Safety notes

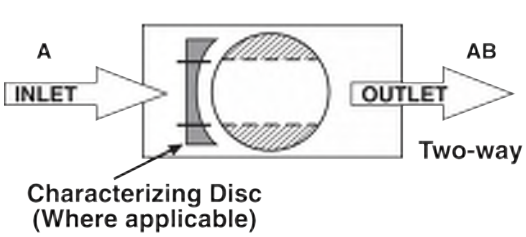
- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov

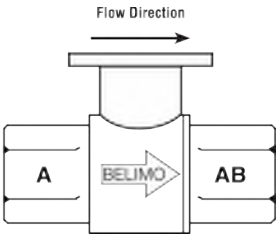
Product features

Application

This valve is typically used in air handling units on heating or cooling coils, and fan coil unit heating or cooling coils. Some other common applications include Unit Ventilators, VAV box re-heat coils and bypass loops. This valve is suitable for use in a hydronic system with variable flow.

Flow/Mounting details

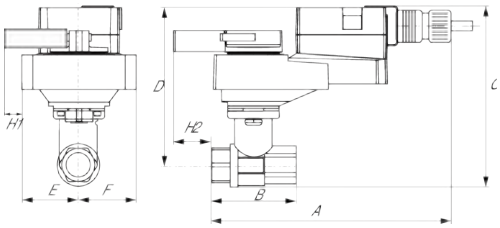




Dimensions

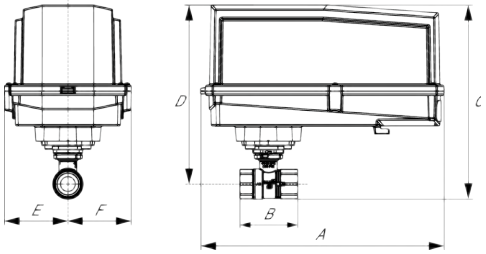
Dimensional drawings

ARB, ARX



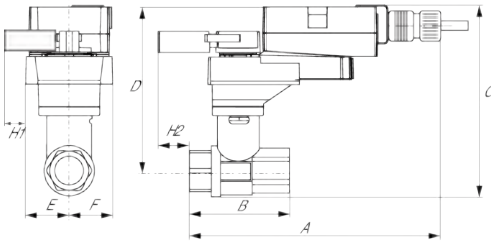
A	B	C	D	E	F	H1	H2
11.0" [280]	3.9" [100]	6.4" [163]	5.3" [134]	1.7" [44]	1.7" [44]	1.2" [30]	0.6" [15]

ARB N4, ARX N4, NRB N4, NRX N4



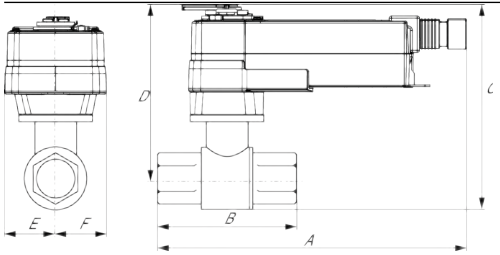
A	B	C	D	E	F
11.4" [289]	3.9" [100]	8.5" [217]	7.3" [185]	3.1" [80]	3.1" [80]

NRQB, NRQX



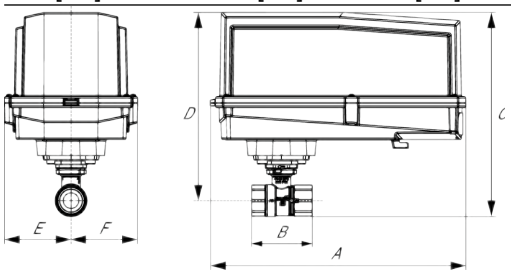
A	B	C	D	E	F	H1	H2
11.0" [280]	3.9" [100]	7.1" [181]	6.0" [152]	1.7" [44]	1.7" [44]	1.4" [34]	0.6" [15]

AFRB, AFRX



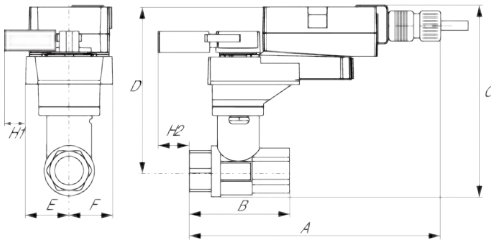
A	B	C	D	E	F
10.8" [275]	3.9" [100]	9.0" [229]	7.8" [198]	2.0" [51]	2.0" [51]

AFRB N4, AFRX N4



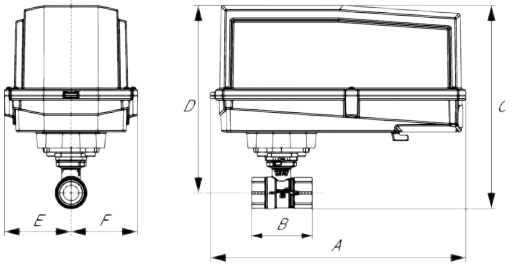
A	B	C	D	E	F
13.0" [330]	3.9" [100]	10.3" [262]	8.5" [216]	3.4" [86]	3.4" [86]

NRQB, NRQX



A	B	C	D	E	F	H1	H2
11.0" [280]	3.9" [100]	7.1" [181]	6.0" [152]	1.7" [44]	1.7" [44]	1.4" [34]	0.6" [15]

AFRB N4, AFRX N4



A	B	C	D	E	F
13.0" [330]	3.9" [100]	10.3" [262]	8.5" [216]	3.4" [86]	3.4" [86]

BELIMO

Technical data sheet ARB24-SR

Modulating, Non-Spring Return, 24 V, for DC 2...10 V or 4...20 mA

5-year warranty

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	2.5 W
	Power consumption in rest position	0.4 W
	Transformer sizing	5 VA (class 2 power source)
	Electrical Connection	18 GA plenum cable, 3 ft [1 m], with 1/2" conduit connector
	Overload Protection	electronic thoughout 0...90° rotation
Functional data	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for 2...10 V (0.1 mA), 500 Ω for 4...20 mA
	Position feedback U	2...10 V
	Direction of motion motor	selectable with switch 0/1
	Manual override	external push button
	Angle of rotation	90°
	Angle of rotation note	adjustable with mechanical stop
	Running Time (Motor)	90 s
	Noise level, motor	45 dB(A)
	Position indication	Mechanically, pluggable
Safety data	Degree of protection IEC/EN	IP54
	Degree of protection NEMA/UL	NEMA 2 UL Enclosure Type 2
	Agency Listing	cULus acc. to UL60730-1A/-2-14, CAN/CSA E60730-1:02, CE acc. to 2014/30/EU
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	2.2 lb [1.0 kg]

Safety notes

- NEMA 4X, 316L stainless steel enclosure.
- Battery Back Up System for SY(7~10)-110
- ZS-300 without brackets.
- Terminal-strip cover for NEMA 2 rating (-T models).
- MFT95 resistor kit for 4 to 20 mA control applications.
- Battery Back Up System for SY(10~12)-220P

Electrical installation

INSTALLATION NOTES

1 Provide overload protection and disconnect as required.

2 Actuators may be connected in parallel. Power consumption and input impedance must be observed.

5 Only connect common to negative (-) leg of control circuits.

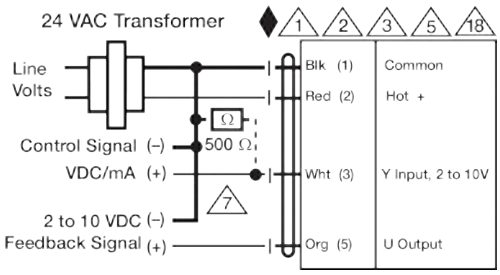
7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.

18 Actuators with plenum cable do not have numbers; use color codes instead.

Meets cULus requirements without the need of an electrical ground connection.

Warning! Live Electrical Components!

During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.



2...10 V / 4...20 mA Control

BELIMO

Stainless Steel Ball and Stem

Technical data sheet B249

5-year warranty

Technical data

Functional data	Valve Size	2" [50]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	0...250°F [-18...120°C]
	Body Pressure Rating	400 psi
	Close-off pressure Δps	200 psi
	Flow characteristic	equal percentage
	Servicing	maintenance-free
	Flow Pattern	2-way
	Leakage rate	0% for A – AB
	Controllable flow range	75°
	Cv	46
	Body pressure rating note	400 psi
Materials	Valve body	Nickel-plated brass body
	Stem seal	EPDM (lubricated)
	Seat	PTFE
	Pipe connection	NPT female ends
	O-ring	EPDM (lubricated)
	Ball	stainless steel
Suitable actuators	Non-Spring	ARB(X)

Safety notes

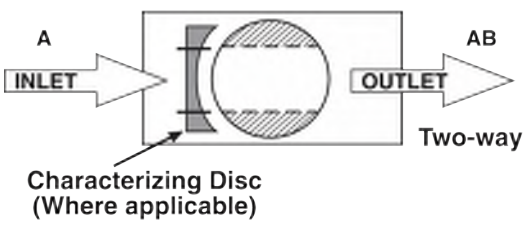
- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov

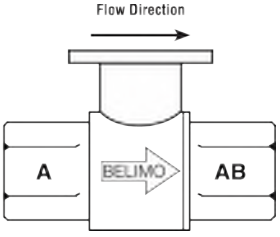
Product features

Application

This valve is typically used in air handling units on heating or cooling coils, and fan coil unit heating or cooling coils. Some other common applications include Unit Ventilators, VAV box re-heat coils and bypass loops. This valve is suitable for use in a hydronic system with variable flow.

Flow/Mounting details

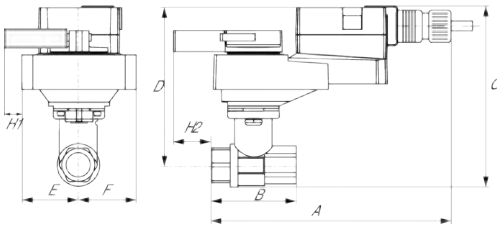




Dimensions

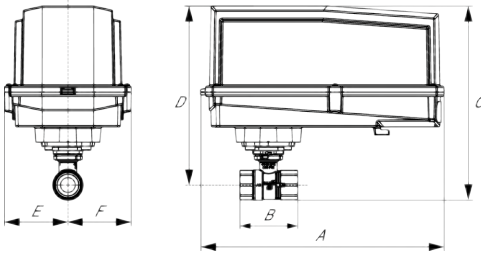
Dimensional drawings

ARB, ARX



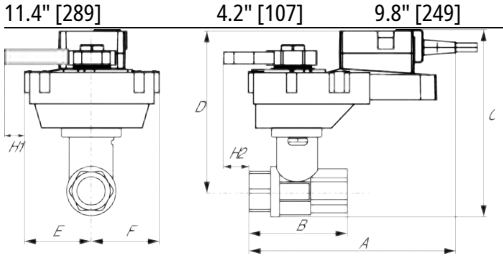
A	B	C	D	E	F	H1	H2
11.0" [280]	4.2" [107]	6.9" [175]	5.5" [140]	1.7" [44]	1.7" [44]	1.2" [30]	0.6" [15]

ARB N4, ARX N4, NRB N4, NRX N4



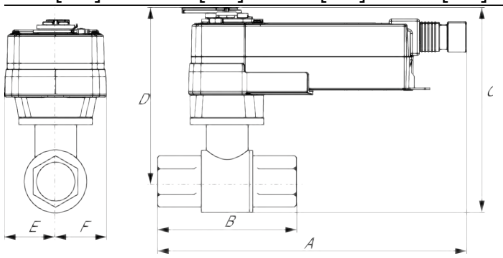
A	B	C	D	E	F
11.4" [289]	4.2" [107]	9.8" [249]	7.6" [194]	3.1" [80]	3.1" [80]

ARQB, ARQX



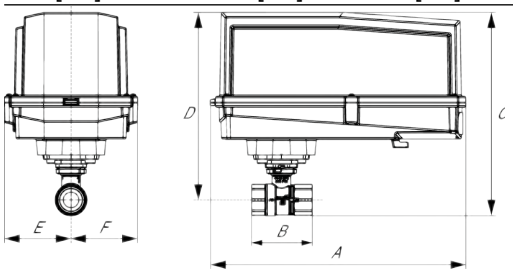
A	B	C	D	E	F	H1	H2
11.0" [280]	4.2" [107]	7.5" [191]	6.1" [155]	2.3" [58]	2.3" [58]	0.8" [20]	0.6" [15]

AFRB, AFRX



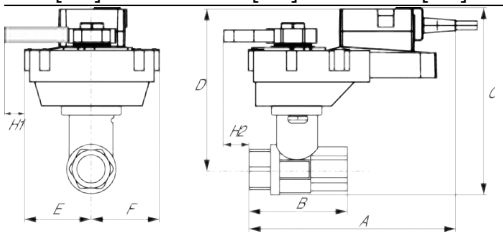
A	B	C	D	E	F
10.8" [275]	4.2" [107]	9.5" [241]	8.1" [206]	2.0" [51]	2.0" [51]

AFRB N4, AFRX N4



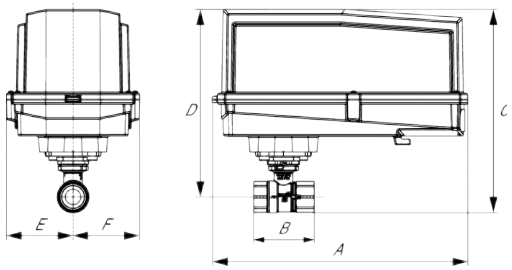
A	B	C	D	E	F
13.0" [330]	4.9" [125]	10.3" [262]	9.3" [235]	3.4" [86]	3.4" [86]

ARQB, ARQX



A	B	C	D	E	F	H1	H2
11.0" [280]	4.2" [107]	7.5" [191]	6.1" [155]	2.3" [58]	2.3" [58]	0.8" [20]	0.6" [15]

AFRB N4, AFRX N4



A	B	C	D	E	F
13.0" [330]	4.9" [125]	10.3" [262]	9.3" [235]	3.4" [86]	3.4" [86]

BELIMO

Modulating, Spring Return, AC 24 V for DC 2...10 V or 4...20 mA Control Signal

Technical data sheet AFRB24-SR

5-year warranty

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	5.5 W
	Power consumption in rest position	3 W
	Transformer sizing	8.5 VA (class 2 power source)
	Electrical Connection	18 GA appliance cable, 3 ft [1 m], with 1/2" conduit connector
	Overload Protection	electronic throughout 0...95° rotation
Functional data	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for 2...10 V (0.1 mA), 500 Ω for 4...20 mA
	Position feedback U	2...10 V
	Position feedback U note	Max. 0.5 mA
	Direction of motion motor	selectable with switch
	Direction of motion fail-safe	reversible with cw/ccw mounting
	Manual override	5 mm hex crank (3/16" Allen), supplied
	Angle of rotation	90°
	Running Time (Motor)	95 s
	Running time fail-safe	<20 s
	Noise level, motor	45 dB(A)
	Noise level, fail-safe	62 dB(A)
	Position indication	Mechanical
Safety data	Degree of protection IEC/EN	IP54
	Degree of protection NEMA/UL	NEMA 2 UL Enclosure Type 2
	Agency Listing	cULus acc. to UL60730-1A/-2-14, CAN/CSA E60730-1:02, CE acc. to 2014/30/EU and 2014/35/EU; Listed to UL 2043 - suitable for use in air plenums per Section 300.22(c) of the NEC and Section 602.2 of the IMC
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	5.4 lb [2.4 kg]

Electrical installation

INSTALLATION NOTES

(A) Actuators with appliance cables are numbered.

1 Provide overload protection and disconnect as required.

3 Actuators may also be powered by 24 VDC.

5 Only connect common to negative (-) leg of control circuits.

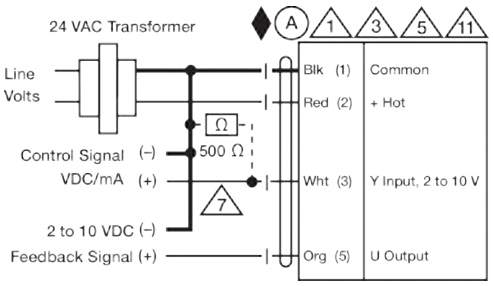
7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.

11 Actuators may be connected in parallel if not mechanically linked. Power consumption and input impedance must be observed.

Meets cULus requirements without the need of an electrical ground connection.

Warning! Live Electrical Components!

During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.



2...10 V / 4...20 mA Control

BELIMO

Stainless Steel Ball and Stem

Technical data sheet B261

5-year warranty

Technical data

Functional data	Valve Size	2.5" [65]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	0...212°F [-18...100°C]
	Body Pressure Rating	400 psi
	Close-off pressure Δps	100 psi
	Flow characteristic	equal percentage
	Servicing	maintenance-free
	Flow Pattern	2-way
	Leakage rate	0% for A – AB
	Controllable flow range	75°
	Cv	60
	Body pressure rating note	400 psi
	Cv Flow Rating	A-port: as stated in chart B-port: 70% of A – AB Cv
Materials	Valve body	Nickel-plated brass body
	Stem seal	EPDM (lubricated)
	Seat	PTFE
	Pipe connection	NPT female ends
	O-ring	EPDM (lubricated)
	Ball	stainless steel
Suitable actuators	Non-Spring	ARB(X)

Safety notes

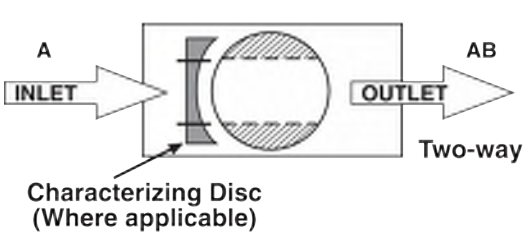
- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov

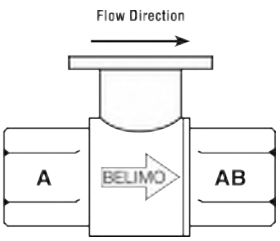
Product features

Application

This valve is typically used in air handling units on heating or cooling coils, and fan coil unit heating or cooling coils. Some other common applications include Unit Ventilators, VAV box re-heat coils and bypass loops. This valve is suitable for use in a hydronic system with variable flow.

Flow/Mounting details

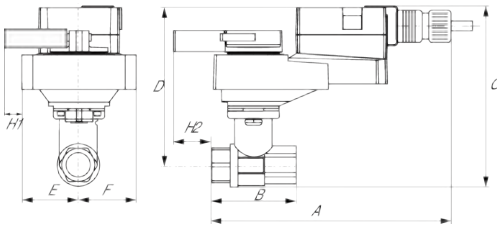




Dimensions

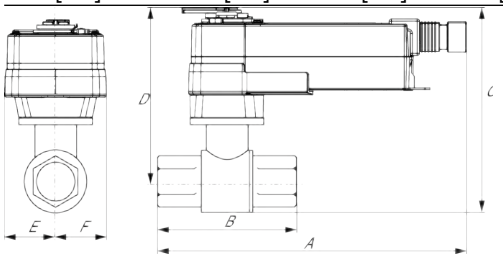
Dimensional drawings

ARB, ARX



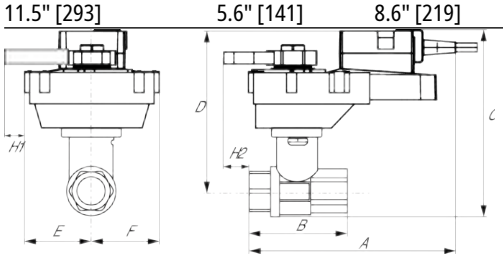
A	B	C	D	E	F	H1
10.1" [257]	5.6" [141]	8.0" [203]	6.0" [152]	2.8" [71]	2.8" [71]	1.9" [48]

AFRB, AFRX



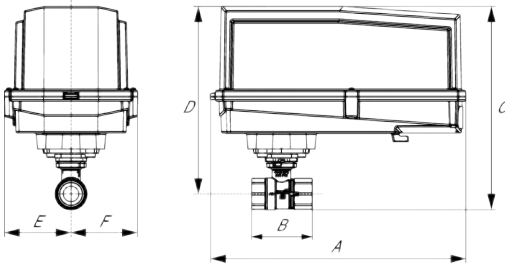
A	B	C	D	E	F
11.5" [293]	5.6" [141]	8.6" [219]	6.6" [168]	2.0" [51]	2.0" [51]

ARQB, ARQX



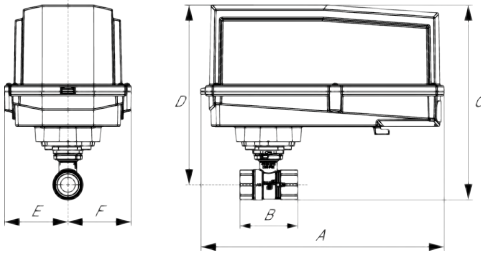
A	B	C	D	E	F	H1	H2
9.9" [251]	4.2" [107]	8.1" [206]	6.1" [155]	2.3" [58]	2.3" [58]	0.8" [20]	0.6" [15]

AFRB N4, AFRX N4



A	B	D	E	F
11.4" [289]	5.6" [141]	8.0" [203]	2.4" [62]	2.4" [62]

ARB N4, ARX N4, NRB N4, NRX N4



A	B	D	E	F
11.4" [289]	5.6" [141]	8.0" [203]	3.1" [80]	3.1" [80]

A	B	C	D	E	F	H1	H2
9.9" [251]	4.2" [107]	8.1" [206]	6.1" [155]	2.3" [58]	2.3" [58]	0.8" [20]	0.6" [15]

A	B	D	E	F
11.4" [289]	5.6" [141]	8.0" [203]	3.1" [80]	3.1" [80]

BELIMO

Modulating, Non-Spring Return, 24 V, Multi-Function Technology®

Technical data sheet ARX24-MFT

5-year warranty

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	3.5 W
	Power consumption in rest position	1.3 W
	Transformer sizing	6 VA (class 2 power source)
	Electrical Connection	18 GA plenum cable with 1/2" conduit connector, degree of protection NEMA 2 / IP54, 3 ft [1 m] 10 ft [3 m] and 16ft [5 m]
	Overload Protection	electronic thoughout 0...90° rotation
Functional data	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for 2...10 V (0.1 mA), 500 Ω for 4...20 mA, 1500 Ω for PWM, On/Off and Floating point
	Operating range Y variable	Start point 0.5...30 V End point 2.5...32 V
	Options positioning signal	variable (VDC, on/off, floating point)
	Position feedback U	2...10 V
	Position feedback U note	Max. 0.5 mA
	Position feedback U variable	VDC variable
	Direction of motion motor	selectable with switch 0/1
	Manual override	external push button
	Angle of rotation	90°
	Angle of rotation note	adjustable with mechanical stop
	Running Time (Motor)	default 150 s, variable 90...150 s
	Running time motor variable	90...150 s
	Noise level, motor	45 dB(A)
	Position indication	Mechanically, pluggable
Safety data	Degree of protection IEC/EN	IP54
	Degree of protection NEMA/UL	NEMA 2 UL Enclosure Type 2
	Agency Listing	cULus acc. to UL60730-1A/-2-14, CAN/CSA E60730-1:02, CE acc. to 2014/30/EU
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	2.6 lb [1.2 kg]

Safety notes

- PVC W'Shld for GV w/UGLK (GM)
- Battery Back Up System for SY(7~10)-110
- 120 to 24 VAC, 40 VA transformer.
- Cable for ZTH US to actuators w/o diagnostics socket.
- 50% voltage divider kit (resistors with wires).
- PC Tool computer programming interface, serial port.

Accessories

Gateways	Description	Type
	Gateway MP to BACnet MS/TP	UK24BAC
	Gateway MP to LonWorks	UK24LON
	Gateway MP to Modbus RTU	UK24MOD

Service tools	Description	Type
	Connection cable 10 ft [3 m], A: RJ11 6/4 ZTH EU, B: 3-pin Weidmüller and supply connection	ZK4-GEN
	Service Tool, with ZIP-USB function, for parametrisable and communicative Belimo actuators, VAV controller and HVAC performance devices	ZTH US

Electrical installation

INSTALLATION NOTES

1 Provide overload protection and disconnect as required.

2 Actuators may be connected in parallel. Power consumption and input impedance must be observed.

3 Actuators may also be powered by 24 VDC.

5 Only connect common to negative (-) leg of control circuits.

7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.

8 Control signal may be pulsed from either the Hot (Source) or Common (Sink) 24 V line.

10 For triac sink the Common connection from the actuator must be connected to the Hot connection of the controller. Position feedback cannot be used with a triac sink controller; the actuator internal common reference is not compatible.

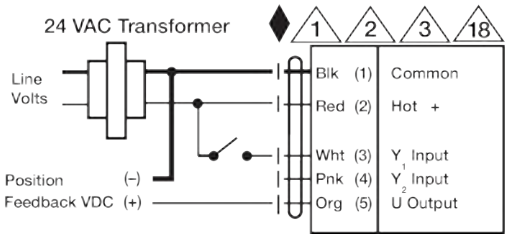
12 IN4004 or IN4007 diode. (IN4007 supplied, Belimo part number 40155).

18 Actuators with plenum cable do not have numbers; use color codes instead.

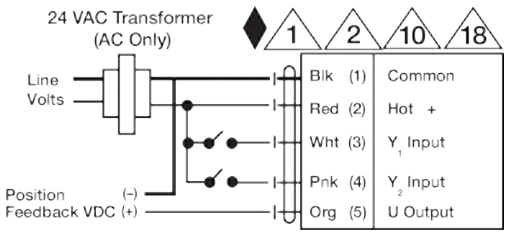
Meets cULus requirements without the need of an electrical ground connection.

Warning! Live Electrical Components!

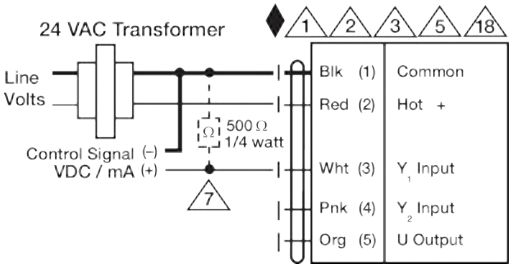
During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.



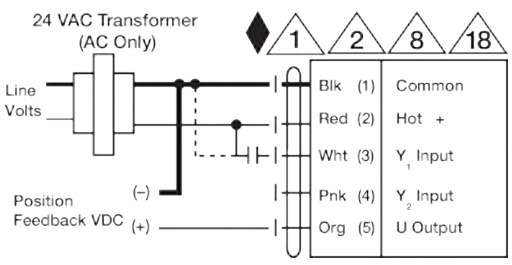
On/Off



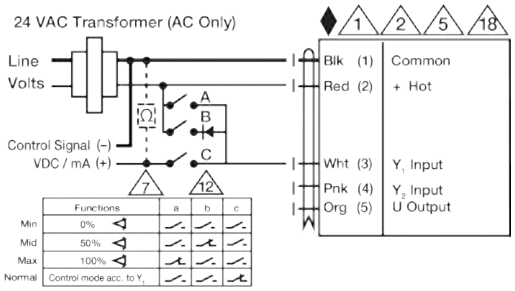
Floating Point



VDC/mA Control



PWM Control

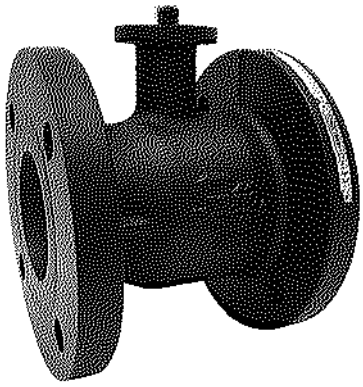


Override Control

BELIMO

Stainless Steel Ball and Stem

Technical data sheet B6250S-070



5-year warranty

Technical data

Functional data	Valve Size	2.5" [65]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	0...250°F [-18...120°C]
	Body Pressure Rating	ANSI Class 125, standard class B
	Close-off pressure Δps	175 psi
	Flow characteristic	equal percentage
	Servicing	maintenance-free
	Flow Pattern	2-way
	Leakage rate	0% for A – AB
	Controllable flow range	75°
	Cv	70
	ANSI Class	125
	Body pressure rating note	standard class B
	Cv Flow Rating	A-port: as stated in chart B-port: 70% of A – AB Cv
Materials	Valve body	Cast iron - GG 25
	Stem seal	EPDM (lubricated)
	Seat	PTFE
	Pipe connection	pattern to mate with ANSI 125 flange
	O-ring	EPDM (lubricated)
	Ball	stainless steel
Suitable actuators	Non-Spring	ARB(X)

Safety notes

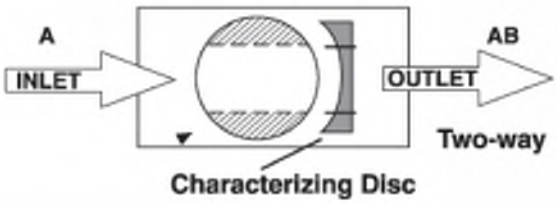
- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov

Product features

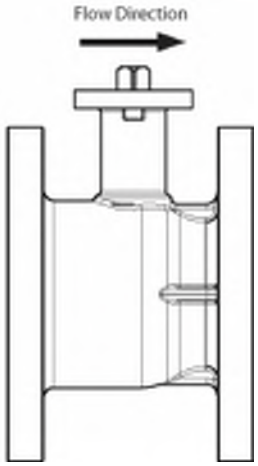
Application

This valve is typically used in air handling units on heating or cooling coils, and fan coil unit heating or cooling coils. Some other common applications include Unit Ventilators, VAV box re-heat coils and bypass loops. This valve is suitable for use in a hydronic system with variable flow.

Flow/Mounting details



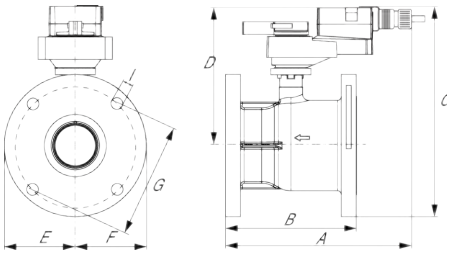
Upstream A
Downstream AB



Dimensions

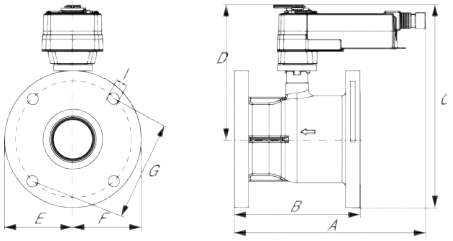
Dimensional drawings

ARB, ARX



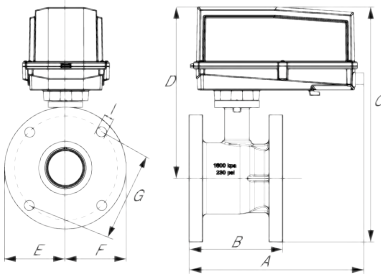
A	B	C	D	E	F	G	I	Number of Bolt Holes
8.3" [211]	5.4" [137]	11.6" [294]	7.8" [198]	3.6" [92]	3.6" [92]	5.5" [140]	0.7" [19]	4

AFRB, AFRX



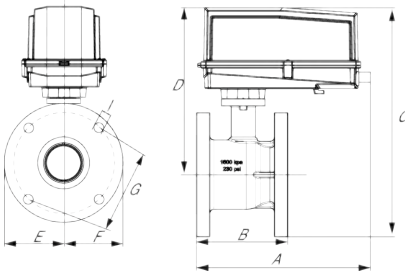
A	B	C	D	E	F	G	I	Number of Bolt Holes
8.3" [211]	5.4" [137]	12.2" [309]	9.4" [239]	3.6" [92]	3.6" [92]	5.5" [140]	0.7" [19]	4

ARX



A	B	C	D	E	F	G	I	Number of Bolt Holes
13.0" [330]	5.4" [137]	15.0" [380]	7.8" [198]	3.6" [92]	3.6" [92]	5.5" [140]	0.7" [19]	4

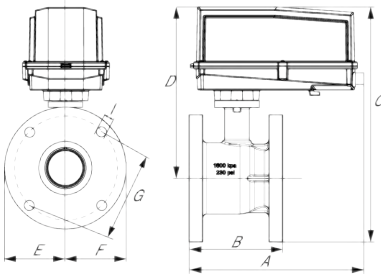
AFRX



A	B	C	D	E	F	G	I	Number of Bolt Holes
14.5" [368]	5.4" [137]	16.6" [422]	11.9" [302]	3.6" [92]	3.6" [92]	5.5" [140]	0.7" [19]	4

A	B	C	D	E	F	G	I	Number of Bolt Holes
14.5" [368]	5.4" [137]	16.6" [422]	11.9" [302]	3.6" [92]	3.6" [92]	5.5" [140]	0.7" [19]	4

ARX



A	B	C	D	E	F	G	I	Number of Bolt Holes
13.0" [330]	5.4" [137]	15.0" [380]	7.8" [198]	3.6" [92]	3.6" [92]	5.5" [140]	0.7" [19]	4

BELIMO

Modulating, Spring Return, 24 V, Multi-Function Technology®

Technical data sheet AFRX24-MFT-S

5-year warranty

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	7.5 W
	Power consumption in rest position	3 W
	Transformer sizing	10 VA (class 2 power source)
	Auxiliary switch	2 x SPDT, 3 A resistive (0.5 A inductive) @ AC 250 V, one set at 10°, one adjustable 10...90°
	Switching capacity auxiliary switch	3 A resistive (0.5 A inductive) @ AC 250 V
	Electrical Connection	(2) 18 GA appliance cables with 1/2" conduit connectors, 3 ft [1 m],
	Overload Protection	electronic throughout 0...95° rotation
Functional data	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for 2...10 V (0.1 mA), 500 Ω for 4...20 mA, 1500 Ω for PWM, On/Off and Floating point
	Operating range Y variable	Start point 0.5...30 V End point 2.5...32 V
	Options positioning signal	variable (VDC, PWM, on/off, floating point)
	Position feedback U	2...10 V
	Position feedback U note	Max. 0.5 mA
	Position feedback U variable	VDC variable
	Direction of motion motor	selectable with switch
	Direction of motion fail-safe	reversible with cw/ccw mounting
	Manual override	5 mm hex crank (3/16" Allen), supplied
	Angle of rotation	90°
	Running Time (Motor)	default 150 s, variable 70...220 s
	Running time motor variable	70...220 s
	Running time fail-safe	<20 s tamb = 68°F [20°C]
	Angle of rotation adaptation	off (default)
	Override control	MIN (minimum position) = 0% MID (intermediate position) = 50% MAX (maximum position) = 100%
	Noise level, motor	45 dB(A)
	Noise level, fail-safe	62 dB(A)
	Position indication	Mechanical
Safety data	Degree of protection IEC/EN	IP54
	Degree of protection NEMA/UL	NEMA 2 UL Enclosure Type 2

	Agency Listing	cULus acc. to UL60730-1A/-2-14, CAN/CSA E60730-1:02, CE acc. to 2014/30/EU and 2014/35/EU; Listed to UL 2043 - suitable for use in air plenums per Section 300.22(c) of the NEC and Section 602.2 of the IMC
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	4.2 lb [1.9 kg]

Accessories

Gateways	**Description**	**Type**
	Gateway MP to BACnet MS/TP	UK24BAC
	Gateway MP to LonWorks	UK24LON
	Gateway MP to Modbus RTU	UK24MOD
Service tools	**Description**	**Type**
	Connection cable 10 ft [3 m], A: RJ11 6/4 ZTH EU, B: 3-pin Weidmüller and supply connection	ZK4-GEN
	Service Tool, with ZIP-USB function, for parametrisable and communicative Belimo actuators, VAV controller and HVAC performance devices	ZTH US

Electrical installation

INSTALLATION NOTES

A Actuators with appliance cables are numbered.

1 Provide overload protection and disconnect as required.

3 Actuators may also be powered by 24 VDC.

4 Two built-in auxiliary switches (2x SPDT), for end position indication, interlock control, fan startup, etc.

5 Only connect common to negative (-) leg of control circuits.

7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.

8 Control signal may be pulsed from either the Hot (Source) or Common (Sink) 24 V line.

10 For triac sink the Common connection from the actuator must be connected to the Hot connection of the controller. Position feedback cannot be used with a triac sink controller; the actuator internal common reference is not compatible.

46 Actuators may be controlled in parallel. Current draw and input impedance must be observed.

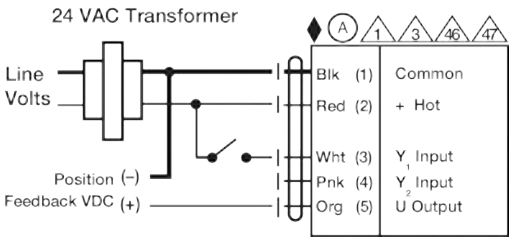
47 Master-Slave wiring required for piggy-back applications. Feedback from Master to control input(s) of Slave(s).

Meets cULus requirements without the need of an electrical ground connection.

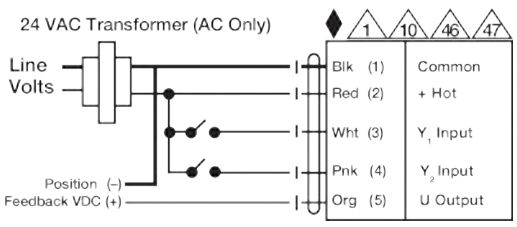
Warning! Live Electrical Components!

During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.

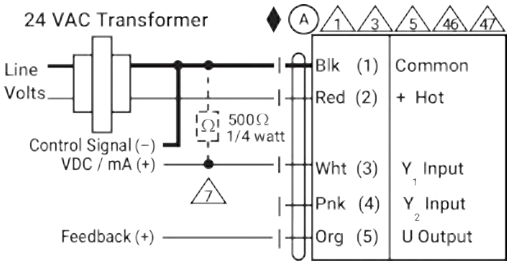
Apply only AC line voltage or only UL-Class 2 voltage to the terminals of auxiliary switches. Mixed or combined operation of line voltage/safety extra low voltage is not allowed.



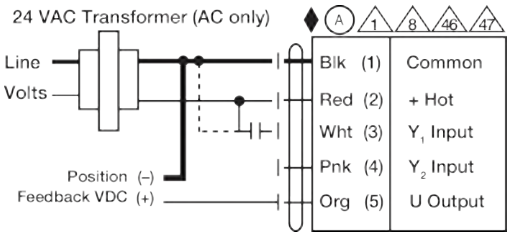
On/Off



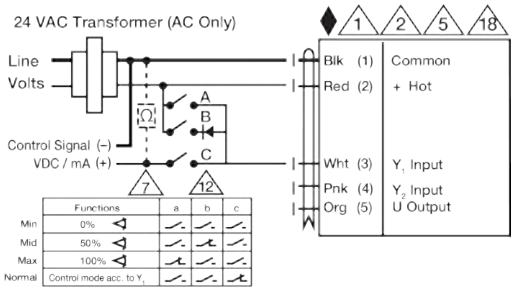
Floating Point



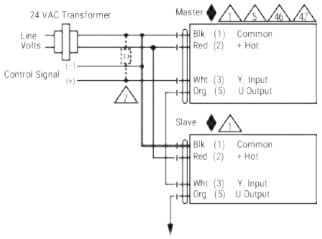
VDC/mA Control



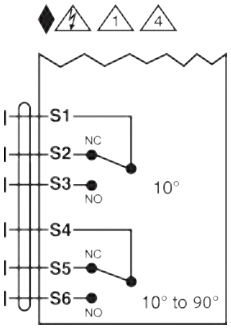
PWM Control



Override Control



Master - Slave



Auxiliary Switches

5-year warranty

Technical data

Functional data	Valve Size	0.5" [15]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	36...212°F [2...100°C]
	Body Pressure Rating	360 psi
	Close-off pressure Δps	75 psi
	Flow characteristic	equal percentage
	Servicing	maintenance-free
	Flow Pattern	2-way
	Leakage rate	0%
	Controllable flow range	75°
	Cv	1.4
	Body pressure rating note	360 psi
Materials	Valve body	forged brass
	Seat	PTFE
	Pipe connection	NPT female ends
	O-ring	EPDM (lubricated)
	Ball	chrome plated brass
Suitable actuators	Non-Spring	CQB
	Electronic fail-safe	CQKB(X)

Safety notes

- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov
- * If temperature exceeds 212°F operating range due to a boiler control failure the valve will safely contain the hot water but manufacturers product warranty becomes invalid. Valve and actuator replacement is at the expense of others.

Product features

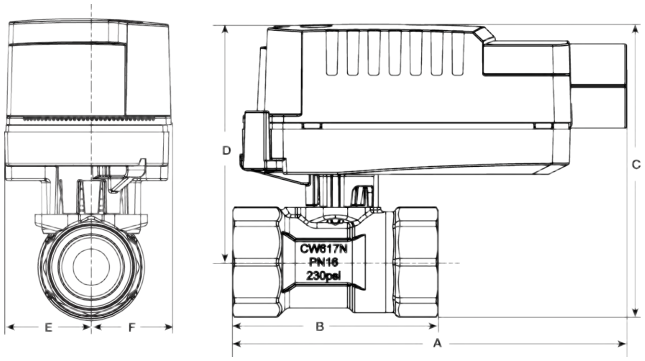
Application

The QCV zone valves are suited for large commercial buildings where higher close-off and the ability to change flow is desired. Common applications include unit ventilators, fan coil units, VAV reheat coils, fin tube casing, radiant panels and duct coils. The valve fits in space restricted areas and can be assembled without the use of tools.

Dimensions

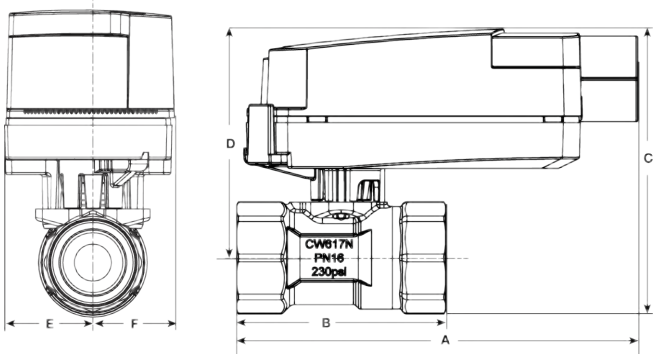
Dimensional drawings

CQK



A	B	C	D	E	F
4.5" [114]	2.0" [52]	3.3" [83]	2.7" [69]	0.9" [24]	24

CQ



A	B	C	D	E	F
4.5" [114]	2.0" [52]	3.1" [80]	2.6" [65]	1.0" [25]	26

BELIMO

On/Off, Floating Point, Non-Spring Return, 24 V

Technical data sheet CQB24-3

5-year warranty

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	0.3 W
	Power consumption in rest position	0.2 W
	Power consumption for wire sizing	0.6 VA
	Transformer sizing	0.6 VA (class 2 power source)
	Electrical Connection	18 GA plenum cable, 3 ft [1 m], with 1/2" conduit connector
	Overload Protection	electronic thoughout 0...90° rotation
Functional data	Angle of rotation	90°, adjustable with mechanical stop
	Angle of rotation note	adjustable with mechanical stop
	Running Time (Motor)	75 s
	Noise level, motor	35 dB(A)
	Position indication	pointer
Safety data	Degree of protection IEC/EN	IP40
	Degree of protection NEMA/UL	NEMA 2 UL Enclosure Type 2
	Agency Listing	cULus acc. to UL60730-1A/-2-14, CAN/CSA E60730-1:02, CE acc. to 2014/30/EU and 2014/35/EU; Listed to UL 2043 - suitable for use in air plenums per Section 300.22(c) of the NEC and Section 602.2 of the IMC
	Quality Standard	ISO 9001
	Ambient temperature	1.7...40°C
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	0.56 lb [0.20 kg]
Materials	Housing material	UL94-5VA

Product features

Application

Non-Fail Safe On/Off/Floating Point ZoneTight actuator.

Valve selection should be done in accordance with the flow parameters and system specifications.

The actuator is mounted directly to the valve without the need for tools or additional linkage.

The actuator operates in response to AC/DC 24 V. Angle of rotation is adjustable with the integrated mechanical stop.

Electrical installation

INSTALLATION NOTES

A Actuators with appliance cables are numbered.

2 Actuators may be connected in parallel. Power consumption and input impedance must be observed.

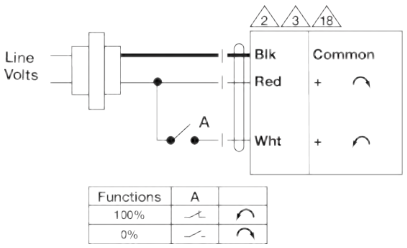
3 Actuators may also be powered by DC 24 V.

18 Actuators with plenum cable do not have numbers; use color codes instead.

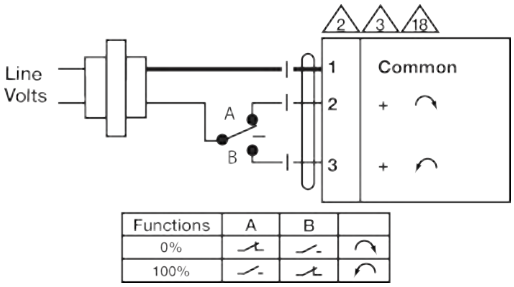
Meets cULus requirements without the need of an electrical ground connection.

Warning! Live electrical components!

During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.



On/Off AC 24 V / DC 24 V AC 24 V Transformer



Floating Point AC 24 V Transformer

5-year warranty

Technical data

Functional data	Valve Size	0.5" [15]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	36...212°F [2...100°C]
	Body Pressure Rating	360 psi
	Close-off pressure Δps	75 psi
	Flow characteristic	equal percentage
	Servicing	maintenance-free
	Flow Pattern	2-way
	Leakage rate	0%
	Controllable flow range	75°
	Cv	1.4
	Body pressure rating note	360 psi
Materials	Valve body	forged brass
	Seat	PTFE
	Pipe connection	NPT female ends
	O-ring	EPDM (lubricated)
	Ball	chrome plated brass
Suitable actuators	Non-Spring	CQB
	Electronic fail-safe	CQKB(X)

Safety notes

- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov
- * If temperature exceeds 212°F operating range due to a boiler control failure the valve will safely contain the hot water but manufacturers product warranty becomes invalid. Valve and actuator replacement is at the expense of others.

Product features

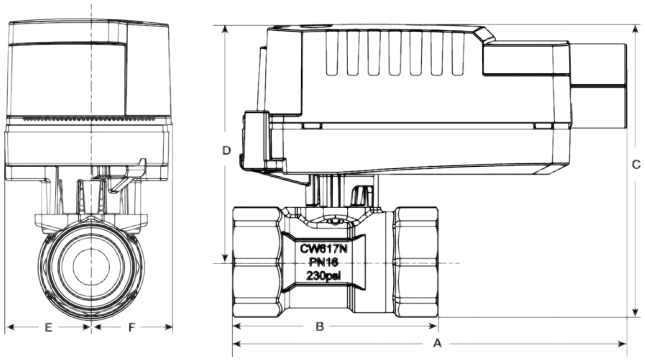
Application

The QCV zone valves are suited for large commercial buildings where higher close-off and the ability to change flow is desired. Common applications include unit ventilators, fan coil units, VAV reheat coils, fin tube casing, radiant panels and duct coils. The valve fits in space restricted areas and can be assembled without the use of tools.

Dimensions

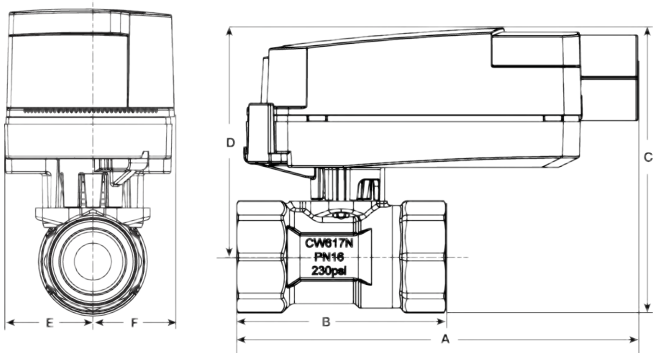
Dimensional drawings

CQK



A	B	C	D	E	F
4.5" [114]	2.0" [52]	3.3" [83]	2.7" [69]	0.9" [24]	0.9" [24]

CQ



A	B	C	D	E	F
4.5" [114]	2.0" [52]	3.1" [80]	2.6" [65]	1.0" [25]	1.0" [26]

BELIMO

Modulating, Non-Spring Return, 24 V, DC 2 V (Close) DC 10 V (Open) or 4...20 mA

Technical data sheet CQB24-SR-R

5-year warranty

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	0.4 W
	Power consumption in rest position	0.3 W
	Transformer sizing	1 VA (class 2 power source)
	Electrical Connection	18 GA plenum cable, 3 ft [1 m], with 1/2" conduit connector
	Overload Protection	electronic thoughout 0...90° rotation
Functional data	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Position feedback U	2...10 V
	Angle of rotation	90°, adjustable with mechanical stop
	Angle of rotation note	adjustable with mechanical stop
	Running Time (Motor)	75 s
	Noise level, motor	35 dB(A)
	Position indication	pointer
Safety data	Degree of protection IEC/EN	IP40
	Degree of protection NEMA/UL	NEMA 2 UL Enclosure Type 2
	Agency Listing	cULus acc. to UL60730-1A/-2-14, CAN/CSA E60730-1:02, CE acc. to 2014/30/EU and 2014/35/EU; Listed to UL 2043 - suitable for use in air plenums per Section 300.22(c) of the NEC and Section 602.2 of the IMC
	Quality Standard	ISO 9001
	Ambient temperature	35...104°F [1.7...40°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	0.55 lb [0.20 kg]
Materials	Housing material	UL94-5VA

Product features

Application

Non-Fail Safe proportional ZoneTight actuator.

Valve selection should be done in accordance with the flow parameters and system specifications.

The actuator is mounted directly to the valve without the need for tools or additional linkage.

The actuator operates in response to a 2...10 V or 4...20mA control signal.

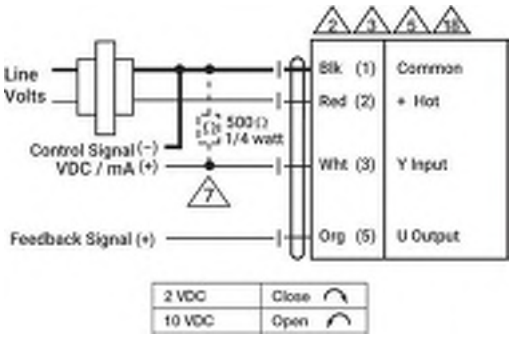
Electrical installation

INSTALLATION NOTES

2 Actuators may be connected in parallel. Power consumption and input impedance must be observed.
3 Actuators may also be powered by 24 VDC.
5 Only connect common to negative (-) leg of control circuits.
7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.
18 Actuators with plenum cable do not have numbers; use color codes instead.
Meets cULus requirements without the need of an electrical ground connection.

Warning! Live Electrical Components!

During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.



AC 24 V Transformer

Submittal #23 09 00-2.0 - HVAC Direct Digital Controls Project Record Documents
23 09 00 - HVAC Direct Digital Controls

Revision	0	**Submittal Manager**	Kristin Larsen (THE WEITZ COMPANY - NEBRASKA)
Status	In Review	**Date Created**	Mar 12, 2021
Issue Date		**Spec Section**	23 09 00 - HVAC Direct Digital Controls
Responsible Contractor	RAY MARTIN COMPANY OF OMAHA	**Received From**	Ken Jambor (RAY MARTIN COMPANY OF OMAHA)
Received Date		**Submit By**	
Final Due Date	May 4, 2021	**Lead Time**	
Sub Job		**Cost Code**	
Location		**Type**	Document
Approvers	Kristin Larsen (THE WEITZ COMPANY - NEBRASKA), Kei'lah Sadler (THE WEITZ COMPANY - NEBRASKA), Chad Liechti (KPE CONSULTING ENGINEERS INC)		
Ball in Court	Chad Liechti (KPE CONSULTING ENGINEERS INC)		
Distribution			
Description	B. Project Record Documents.		

Submittal Workflow

Name	Sent Date	Due Date	Returned Date	Response	Attachments
General Information Attachments					
Ken Jambor	Jun 10, 2021	Apr 2, 2021	Jun 10, 2021	Submitted	OPS Blackburn Submittal.pdf
Kristin Larsen	Jun 10, 2021	Apr 20, 2021	Jun 10, 2021	Approved	23 0900-002-00 HVAC DDC Controls Drawings.pdf (Current)
Kei'lah Sadler	Jun 10, 2021	Apr 20, 2021		Pending	
Chad Liechti	Jun 10, 2021	May 4, 2021		Pending	

WEITZ
Nebraska Office
8715 S. 121st Street
LaVista, Nebraska 68128

SUBMITTAL REVIEW

The Weitz Companies review ONLY covers coordination of work and layout. Conformance with design concept documents is not checked. Weitz review does not relieve the subcontractor and/or supplier of their contractual requirements. Subcontractor must confirm that the material and equipment meets all contractual requirements.

☑ Reviewed ☐ Reviewed & Noted ☐ Rejected

By: LarsenK Date: 06/10/2021

Submittal No: 23 0900-002-00 HVAC DDC Controls Drawings

DOCUMENT REVIEW

CORRECTION OR COMMENTS MADE ON THE SHOP DRAWINGS DO NOT RELIEVE THE CONTRACTOR FROM COMPLIANCE WITH THE REQUIREMENTS OF THE DRAWINGS AND SPECIFICATIONS. THIS REVIEW IS FOR GENERAL COMPLIANCE WITH THE CONTRACT DOCUMENTS. THE CONTRACTOR IS RESPONSIBLE FOR CONFIRMING ALL QUANTITIES AND DIMENSIONS, SELECTING FABRICATION PROCESSES AND TECHNIQUES OF CONSTRUCTION AND COORDINATING THE WORK WITH ALL OTHER TRADES.

☐ REVIEWED ☐ REVISE & RESUBMIT

☒ REVIEWED & NOTED

KPE ENGINEERS·ARCHITECTS FORENSIC EXPERTS

REVIEWED BY: CTL DATE:06/24/2021

NOTES:

-Hot water reset shall have adjustabe setpoints on the variables of OA and water temperature.

- On AHU's provide monitoring of the return mixed air temperature.

- Owner has requested for combination Temp, CO2, and humidity sensors where the plans show CO2 sensors. The humidity and CO2 shall be able to be monitored on control interface. Rooms to include these sensors are:
Corridor 1051B
Classroom HS 107
Gymnasium 1100
Cafeteria 123
Music 504
Art 508-East
Classroom 209
Media Center 300
Classroom 411
Classroom 406
Confirm with Owners rep.

- Chiller Sequence, The DDC shall enable the chiller after the start of the chilled water pumps

- Cabinet and unit heaters shall control fans to operate upon a call of heating and shall be off when setpoint is satisfied.

- Clarify chilled water pump if this is secondary pump system.

- Provide a status for the fan coil units.
- FCU fans to run on building schedule during occupied mode. Off during unoccupied unless a call for heating or cooling.

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Telephone: (402) 333-9800 Fax: (402) 333-9881

SECTION 23 09 00:
HVAC INSTRUMENTATION AND CONTROLS

SUBMITTALS

OPS BLACKBURN

OPS BLACKBURN

OMAHA, NEBRASKA

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REVISIONS

PROJECT: RS21-29 BER

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DRAWING:

TITLE PAGE

DATE:

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SENSOR SYMBOLS

- DUCT PROBE TEMPERATURE
- DUCT AVERAGING TEMPERATURE
- OUTDOOR TEMPERATURE
- WELL INSERTION TEMPERATURE
- REMOTE BULB TEMPERATURE
- SPACE TEMPERATURE
- PIPE STRAP-ON TEMPERATURE
- DUCT PROBE HUMIDITY
- OUTDOOR HUMIDITY
- SPACE HUMIDITY
- DIFFERENTIAL STATIC PRESSURE (PANEL MOUNT)
- DIFFERENTIAL STATIC PRESSURE (DUCT MOUNT)
- PIPE TAP PRESSURE (ABSOLUTE)
- SPACE STATIC PRESSURE
- AIR FLOW STATION (F)
- PICK-UP TUBES (F)
- CURRENT SENSOR (CT)
- LEVEL SENSOR (FLOAT)
- LEVEL SENSOR (ELECTRONIC)
- DUCT SMOKE DETECTOR

ACTUATOR SYMBOLS

- ELECTRIC - 24Vac (24)

NOTE:
FC = FAIL CLOSED
FO = FAIL OPEN
FL = FAIL LAST

VALVE SYMBOLS

- 3-WAY VALVE

NOTE:
NORMALLY CLOSED A-AB

- 2-WAY VALVE

NOTE:
NORMALLY CLOSED A-B

MECHANICAL SYMBOLS

- DUCT
- VAV BOX (VAV Box)
- FAN COIL UNIT
- FAN
- DAMPER (OPPOSED BLADE)
- DAMPER (PARALEL BLADE)
- HEATING COIL (HOT WATER OR STEAM)
- HEATING COIL (ELECTRIC, 3-PHASE) (3)
- COOLING COIL (CHILLED WATER)
- COOLING COIL (DX) (D, X)
- HEATING/COOLING COIL (HOT OR CHILLED WATER)
- PUMP
- VARIABLE FREQUENCY DRIVE (VFD)
- HEAT EXCHANGER
- BOILER (Boiler)
- CHILLER (Chiller)

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LEGEND

DATE:

6/10/2021

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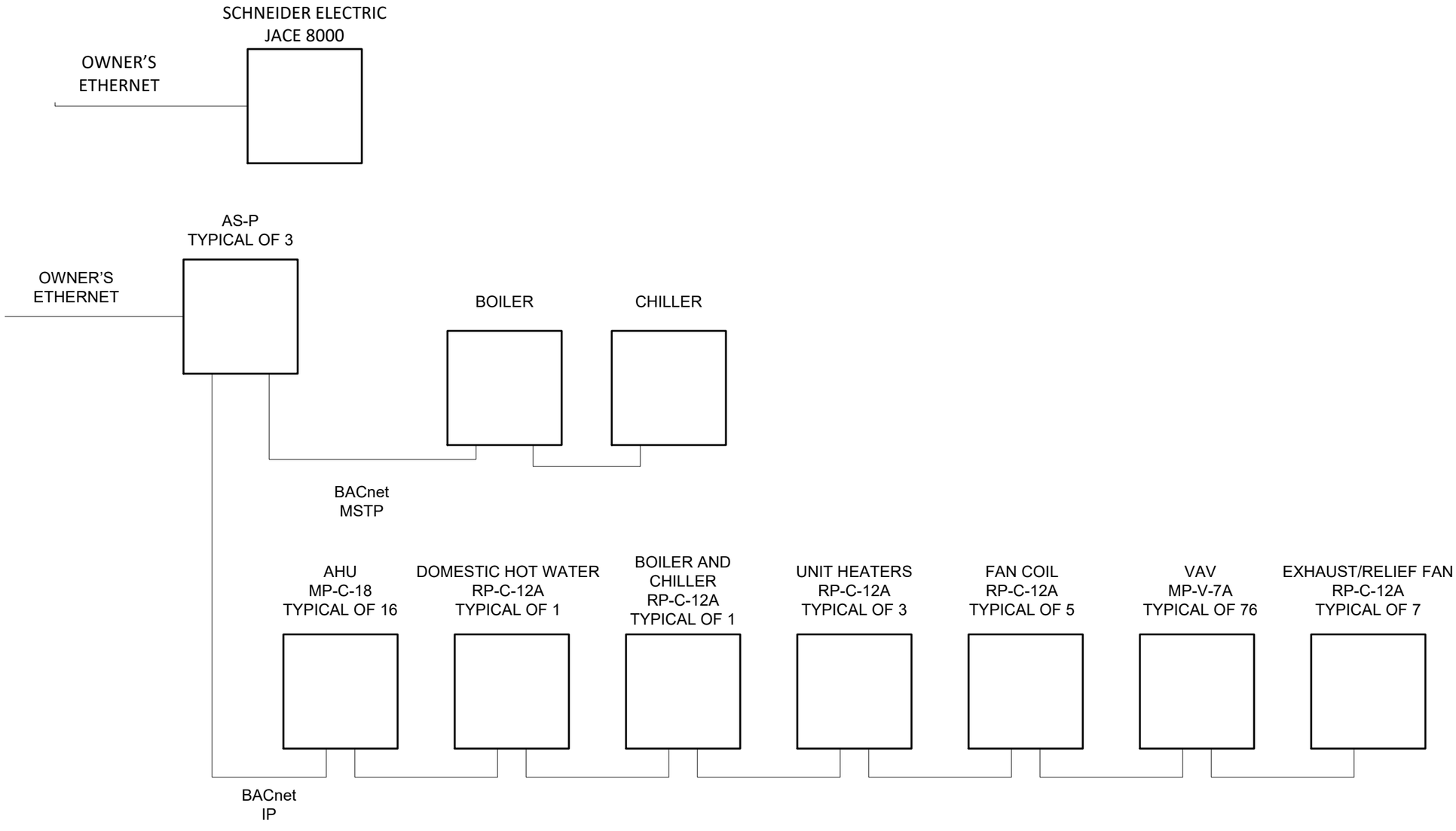

* Drawing of system architecture is diagrammatic only. Actual number of Schneider Electric Automation Servers (AS-Ps) and layout of Schneider Electric Smart X BACnet IP controllers will be updated on As Built Drawings.

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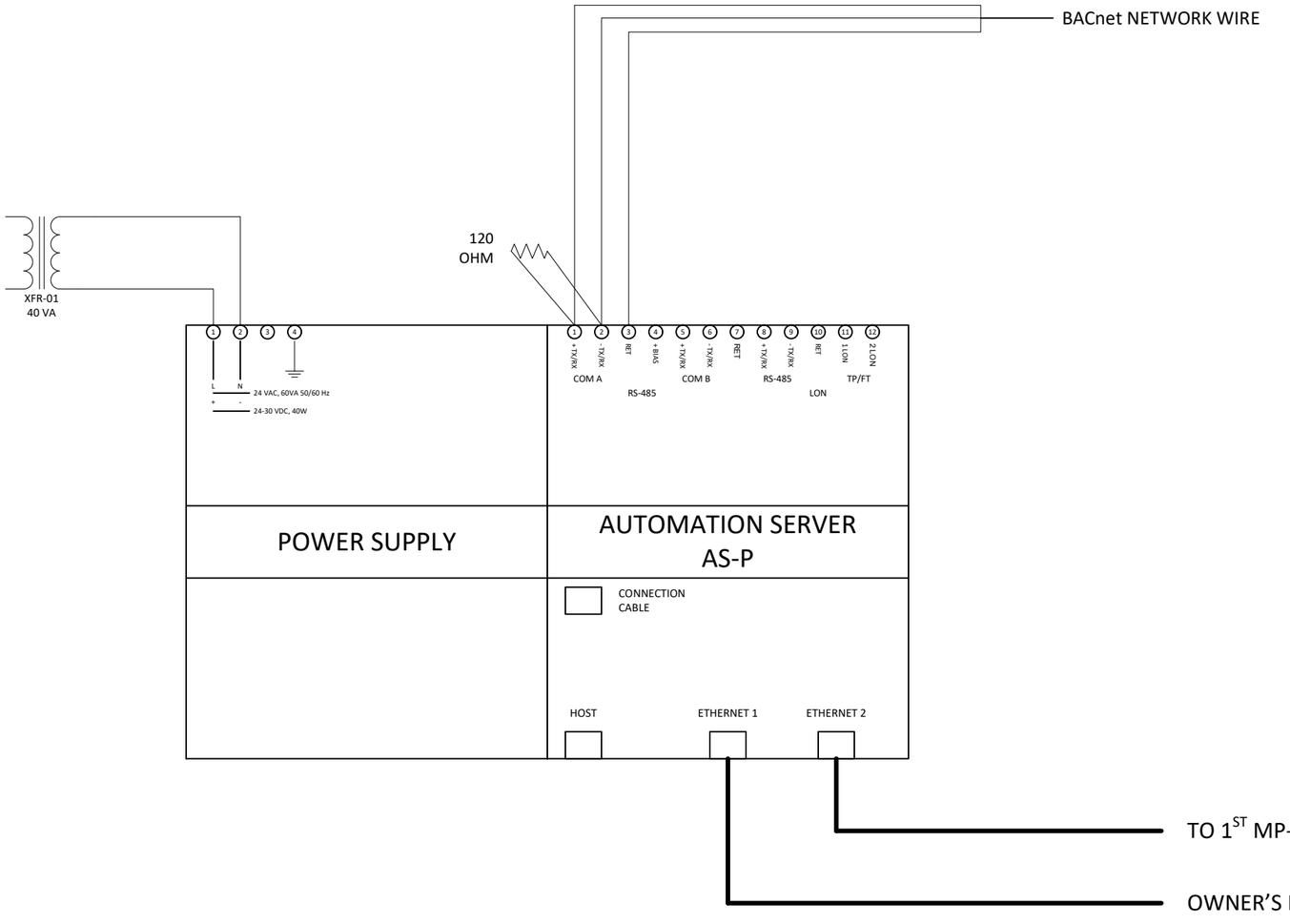
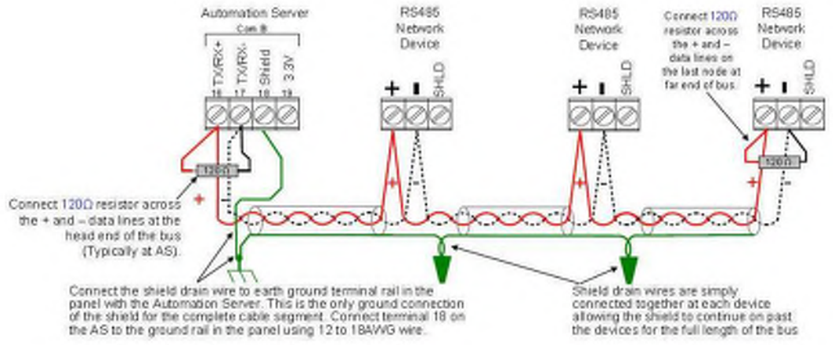
NETWORK DETAIL

DATE:

6/10/2021



BACnet NETWORK WIRE
DETAIL



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BILL OF MATERIALS

QTY	PART NUMBER
1	AUTOMATION SERVER

BY	CHANGE	DATE

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PROJECT: RS21-29 BER

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AS DETAIL

DATE:

6/10/2021

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AHU SEQUENCE

a. Provide individual master software points for each of the following functions that can be executed from a single command through the DDC system:

1) Command all AHU heating valves open (morning warm up).
2) Command all AHU heating valves closed.
3) Command all AHU cooling valves open.

4) Command all AHU cooling valves closed.

b. Provide a DDC duct temperature sensor and controller to control modulating control valves for hot water and for chilled water to maintain discharge air temperature. Provide separate heating and cooling setpoints. When the discharge air temperature is below setpoint, the DDC controller shall modulate the chilled water valve closed. When the discharge air temperature is above setpoint, the DDC controller shall modulate the hot water valve closed. Provide DDC start/stop for fan control. Cycle fan on when calling for heating or cooling during unoccupied hours. The heating and cooling coil valves shall be commanded closed whenever the AHU is off.

c. Outside Air damper and Return Air damper shall be controlled for minimum OA setpoint during occupied hours. AHU shall also have economizer control.

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BILL OF MATERIALS

QTY	PART NUMBER

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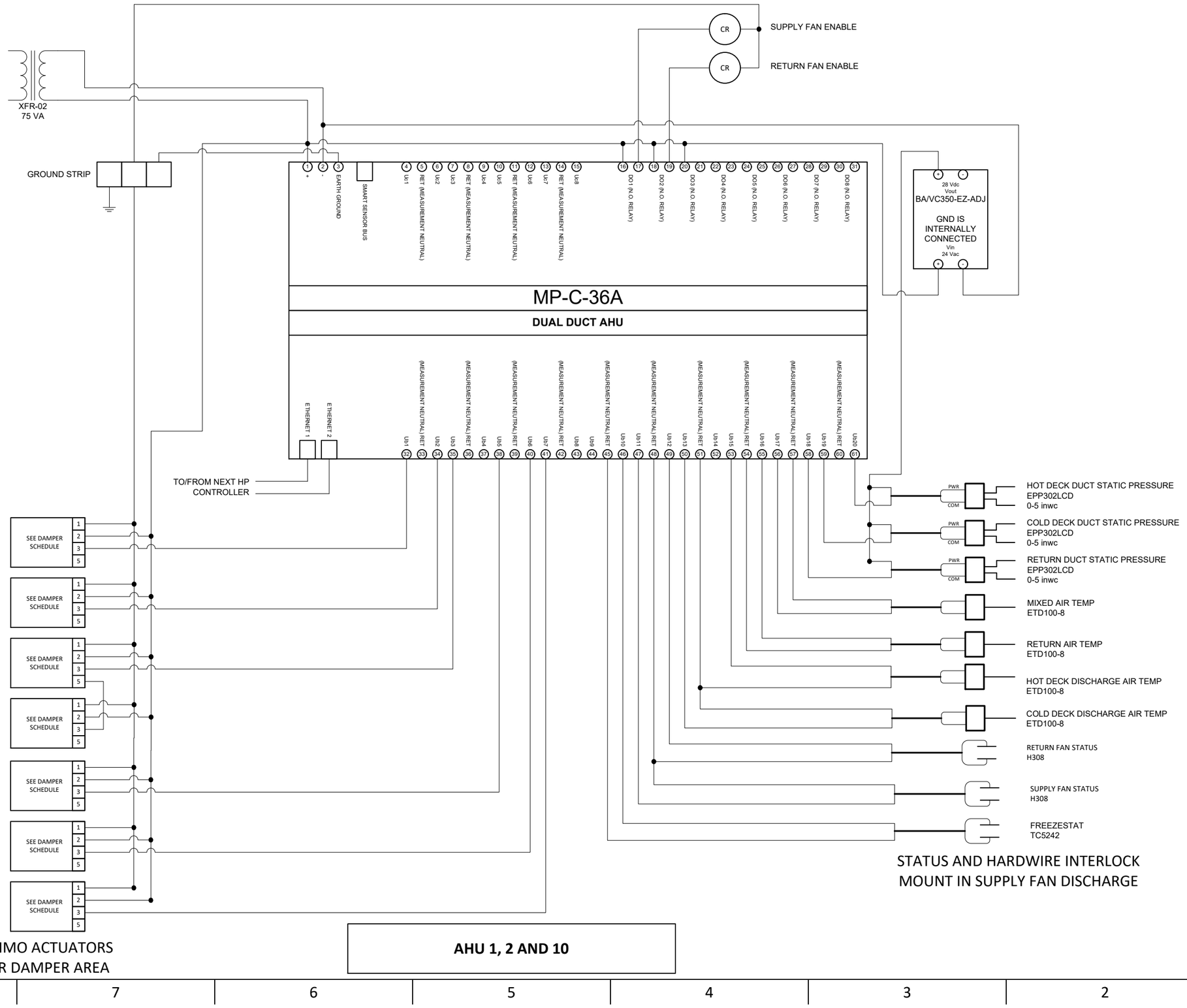

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BILL OF MATERIALS

QTY	PART NUMBER
16	MP-C-18
16	EPP302
16	EPW104
48	ETD110-4
16	H308
16	TC5242

BY	CHANGE	DATE

REVISIONS

PROJECT: RS21-29 | BER

OPS BLACKBURN

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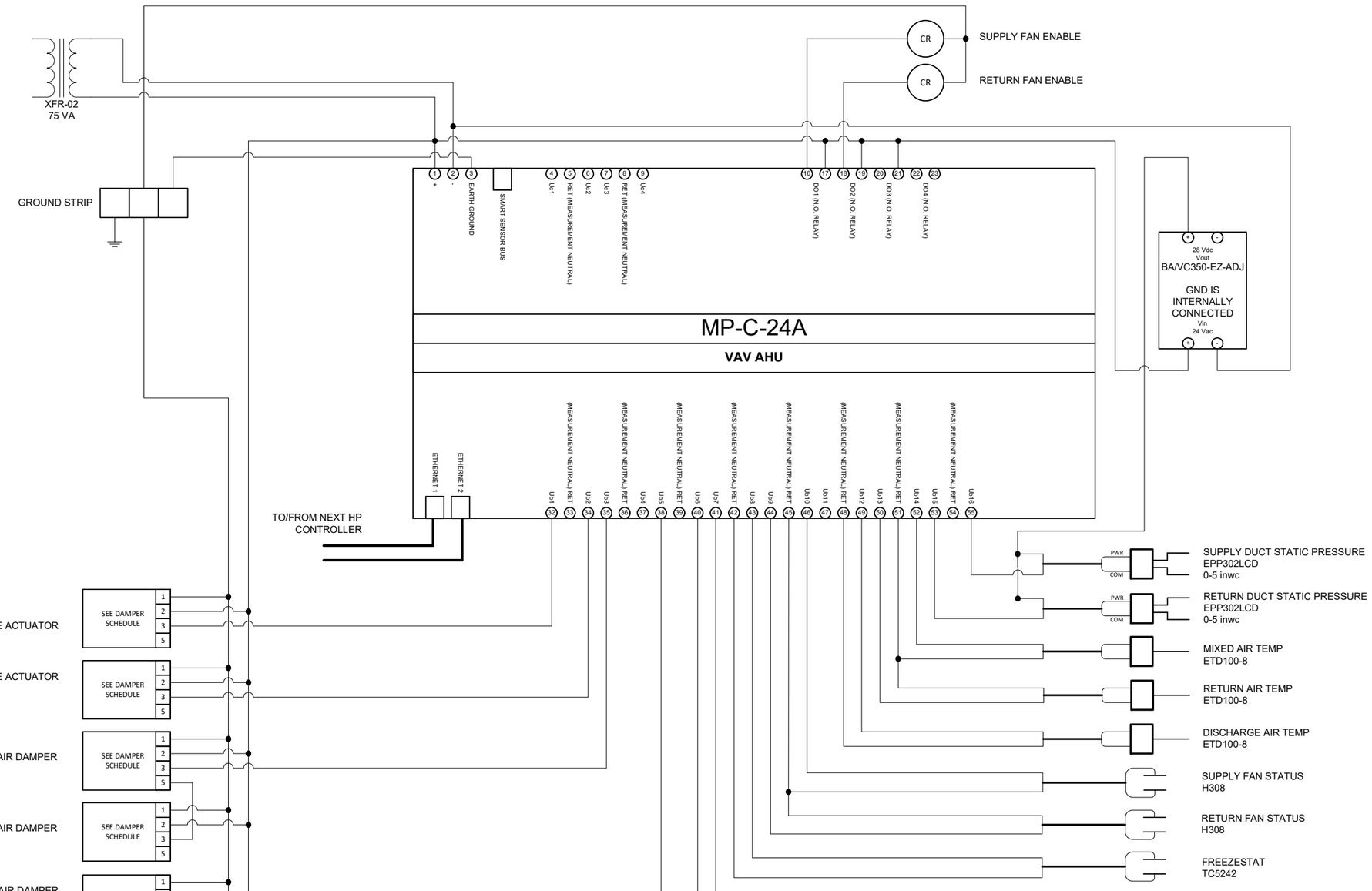

STATUS AND HARDWIRE INTERLOCK

SPRING RETURN BELIMO ACTUATORS
PROPERLY SIZED FOR DAMPER AREA

AHU 3, 4 AND 9

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BILL OF MATERIALS

QTY	PART NUMBER
16	MP-C-18
16	EPP302
16	EPW104
48	ETD110-4
16	H308
16	TC5242

BY	CHANGE	DATE

REVISIONS

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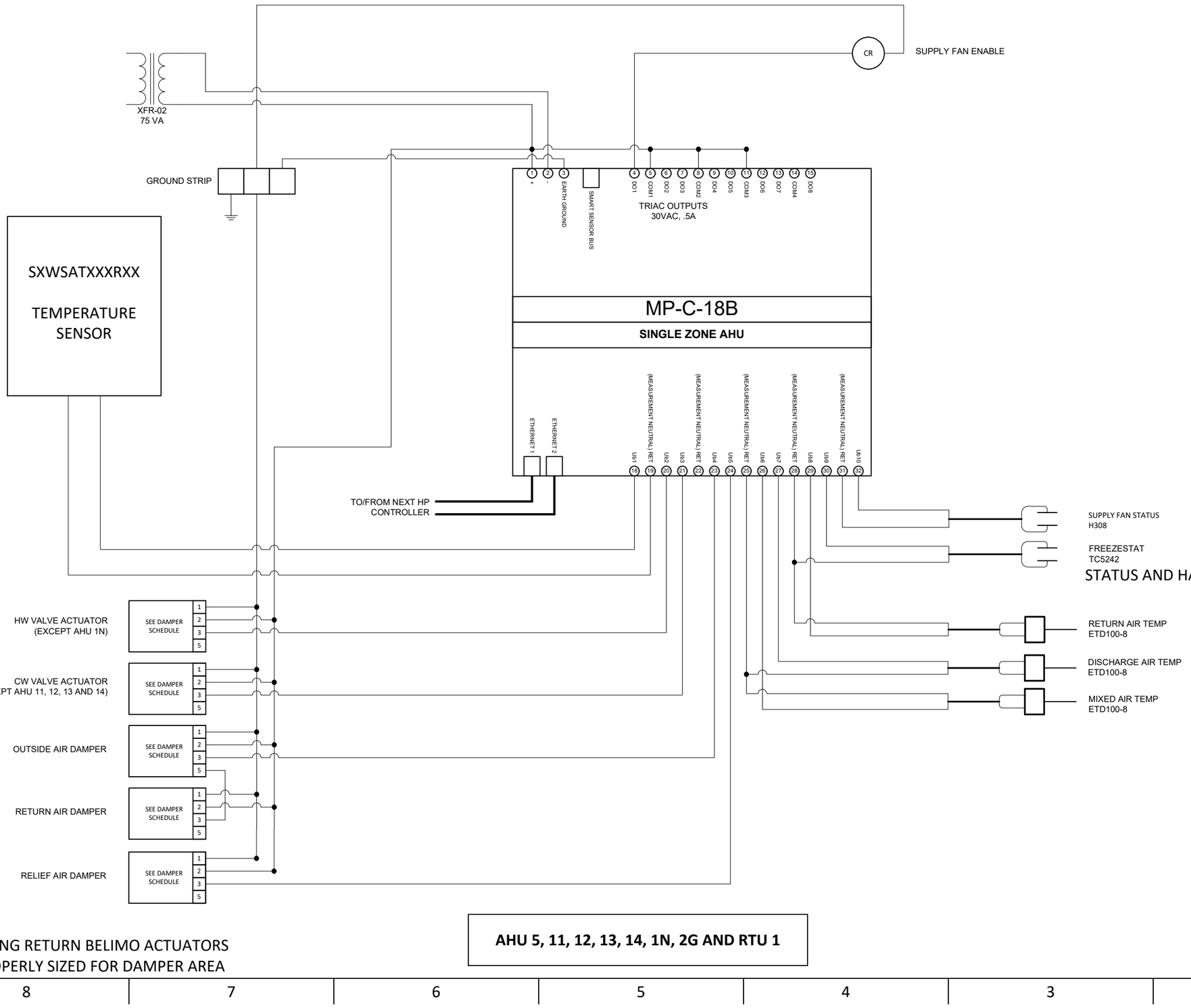

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BILL OF MATERIALS

QTY	PART NUMBER
16	MP-C-18
16	EPP302
16	EPW104
48	ETD110-4
16	H308
16	TC5242

BY	CHANGE	DATE

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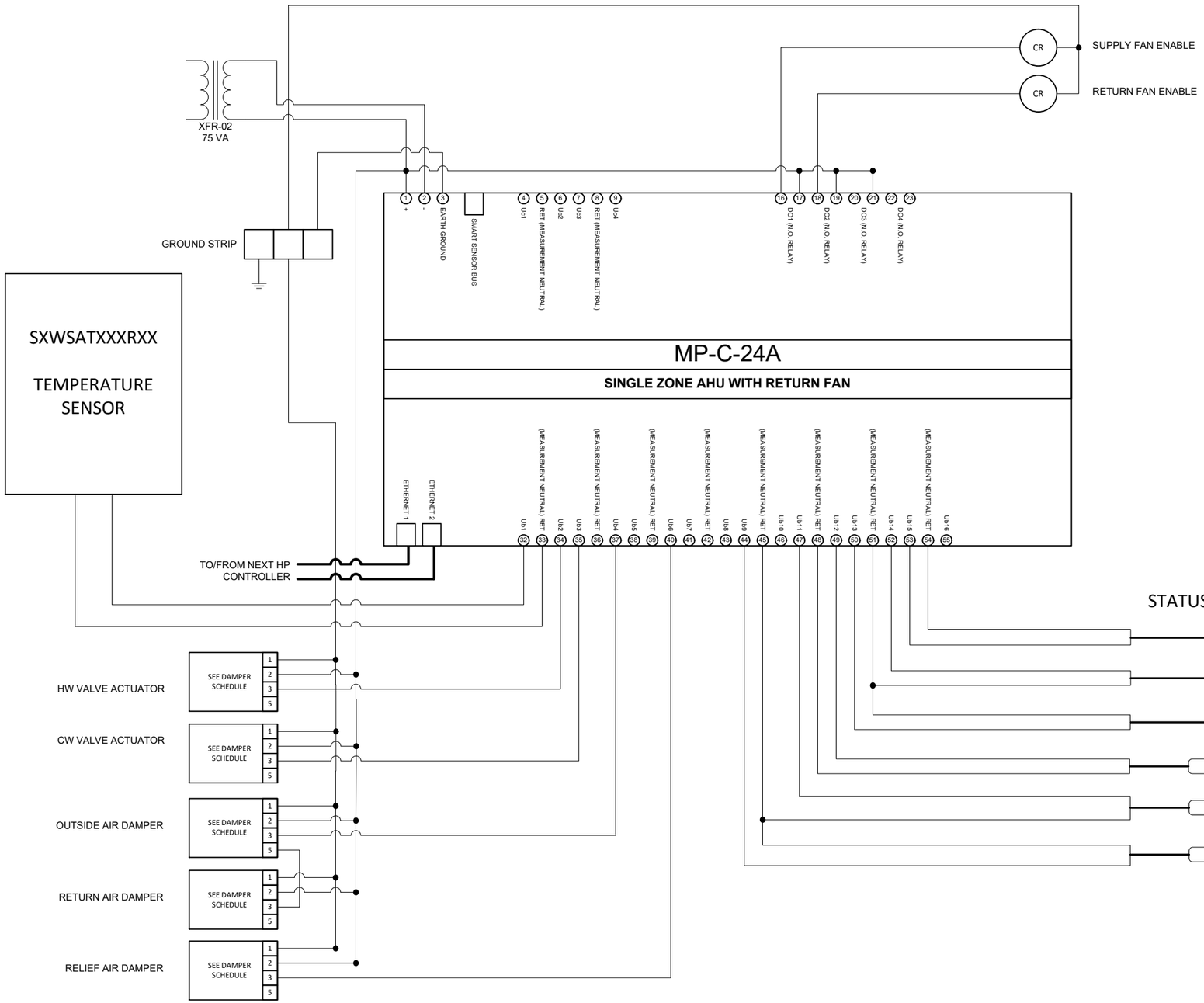

SPRING RETURN BELIMO ACTUATORS
PROPERLY SIZED FOR DAMPER AREA

AHU 6, 7 AND 8

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BILL OF MATERIALS

QTY	PART NUMBER
16	MP-C-18
16	EPP302
16	EPW104
48	ETD110-4
16	H308
16	TC5242

BY	CHANGE	DATE

REVISIONS

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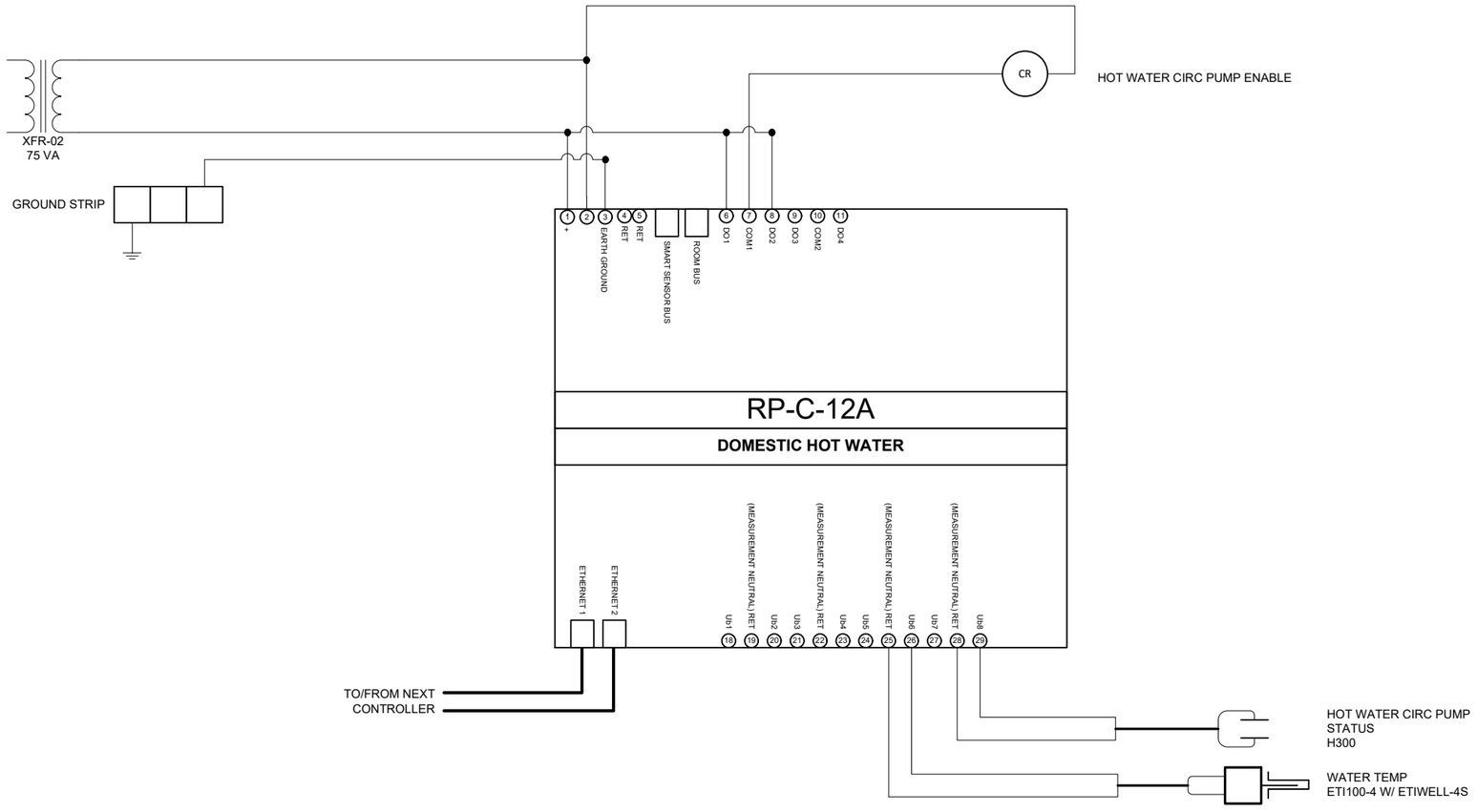

DOMESTIC HOT WATER SEQUENCE

B. DOMESTIC HOT WATER

1. Monitoring: Domestic hot water recirculation pump
2. Control: Enable Disable: Scheduled control.

TYPICAL OF 1

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BILL OF MATERIALS

QTY	PART NUMBER
1	RP-C-12A
1	ETI100-4/ETI-WELL-4S
1	BA/VC350-EZ-ADJ
1	EPG103-AV
1	H614
1	H300

BY	CHANGE	DATE

REVISIONS

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DATE:

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BOILER SEQUENCE

1. B-1 and B-2 Control:

   a. Boiler system shall be enabled during Heating mode and disabled during Cooling mode.

   b. Prior to boiler firing, DDC system shall open combustion air damper. Upon status of open (end switch) DDC shall enable boiler operation.

   d. Prior to boiler firing, DDC system shall open combustion air damper. Upon status of open DDC shall enable boiler operation.

   e. Signal from emergency stop shall shutdown boilers.

   f. Monitoring: On/Off status, common trouble alarm, low-water-level alarm

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BILL OF MATERIALS

QTY	PART NUMBER

BY	CHANGE	DATE

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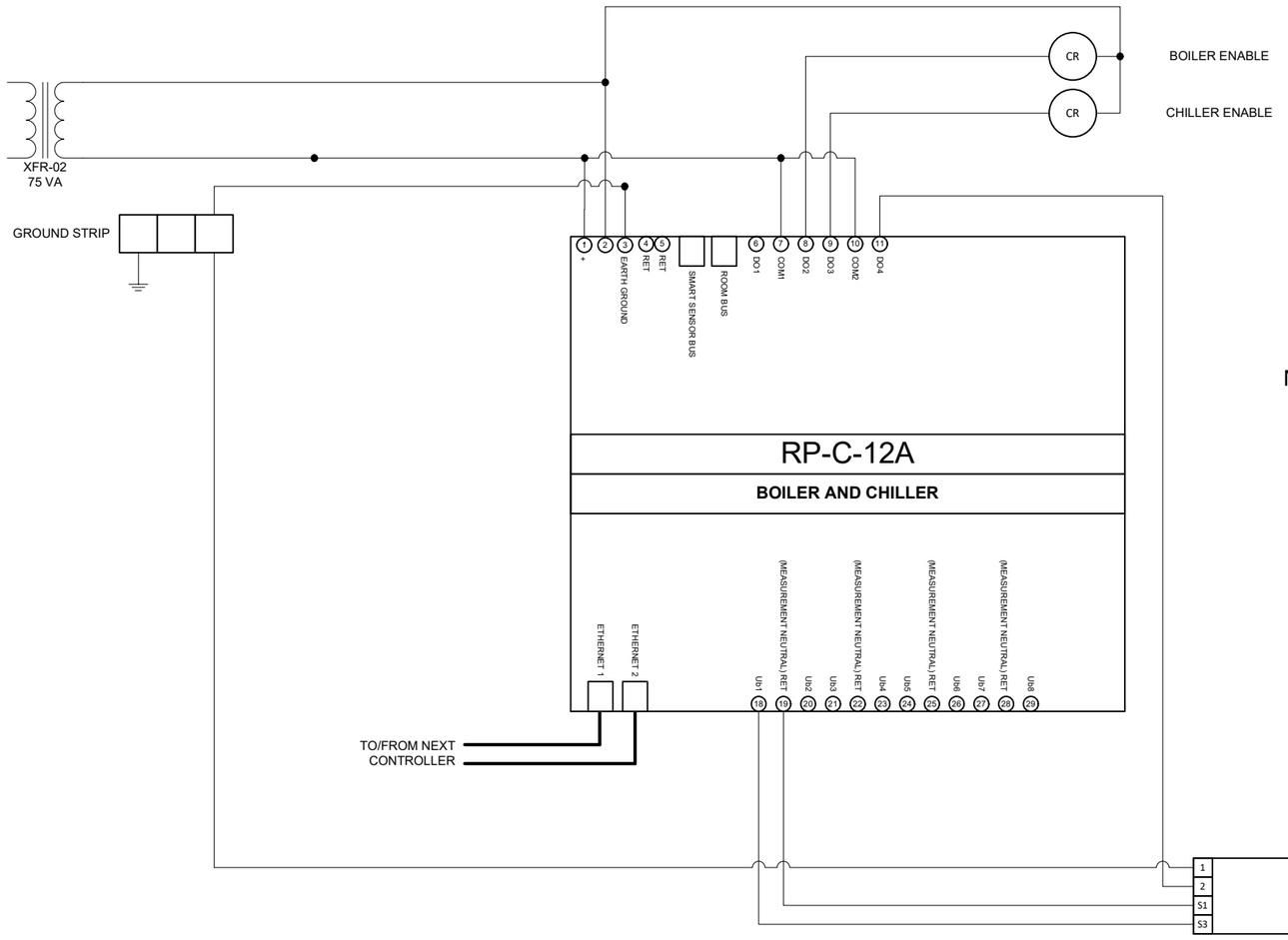

NOTE: BOILER EMERGENCY SHUTDOWN BY ELECTRICAL

OTHER BOILER POINTS FROM BACNET INTERFACE

OTHER CHILLER POINTS FROM BACNET INTERFACE

BELIMO DAMPER ACTUATOR WITH END SWITCH SIZED FOR DAMPER AREA
END SWITCH INTERLOCKED TO BOILER START

TYPICAL OF 1

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BILL OF MATERIALS

QTY	PART NUMBER
2	RP-C-12A
2	EPW104
2	H308

BY	CHANGE	DATE

REVISIONS

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HWP & CWP SEQUENCE

1. Pump (HWP-1) and Pump (HWP-2) Control:

   a. Start/Stop: The DDC system shall start the lead pump whenever the outside air temperature is below []. The lag pump shall normally remain off. Hot water pumps shall be commanded off if all associated AHU's are off and the outside air temperature is above 50° F.
   b. Lead / Lag Control: Current status switches, either integral to the VFD and/or discreet devices, shall prove lead and lag pump operation. If the lead pump is called to run and the current status switch indicates that the lead pump is not operating for 30 seconds (adj.), an alarm shall be sent to the operator interface and the DDC system shall start the lag pump. The lead pump shall maintain a call to run even when in alarm. Upon sensing the lead pump is operating, the lag pump shall be stopped. The DDC system shall index the lag pump to become the lead pump through weekly scheduling feature of the building automation system.

CENTRAL CHILLER PLANT CONTROL:

1. GENERAL:

   a. The Central Chiller Plant consists of a water chiller with dedicated chilled water pumps.
   b. There is one air cooled condenser with condenser fans.
   c. There are two chilled water pumps. One pump shall provide the required chilled water to the buildings to satisfy the peak cooling demand. One pump is redundant and used if there is a pump failure.
   d. Chiller Point Integration: The chiller shall be integrated to the DDC system through a BACnet protocol as specified in the chiller specification Section. Provide DDC programming to define all chiller input and output information available through the chiller manufacturer's integration data port. Some chiller information can be left unmapped if requested by the user Agency.

2. CHILLER ENABLE:

   a. When outside air temperature is greater than 57 °F (adj.), the chiller shall be enabled. The chiller unit mounted controls shall start the primary chilled water pump. The chiller unit mounted controls shall monitor its evaporator flow and safety statuses and shall provide a chiller failure alarm in the event of a flow or safety failure. Minimum chiller runtime shall be 30 minutes (adj.).

3. CHILLED WATER PUMP CONTROL:

   a. Start/Stop: The DDC system shall enable the chilled water pumps when a chiller status is on. The chilled water pump start/stop relays shall utilize normally open contacts so upon failure of the relay or DDC controller the pump shall fail off.
   b. Lead / Lag / Standby Control: Current status switches shall prove lead and lag pump operation. If the lead pump is called to run and the current status switch indicates that the lead pump is not operating for 30 seconds (adj.), an alarm shall be sent to the operator interface and the DDC system shall start the lag pump. The lead pump shall maintain a call to run even when in alarm. Upon sensing a failed pump is again operating, the lag pump shall be stopped. The DDC system shall index the lead pump through weekly scheduling feature of the building automation system or manually as determined by an operator.

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BILL OF MATERIALS

QTY	PART NUMBER

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DATE:

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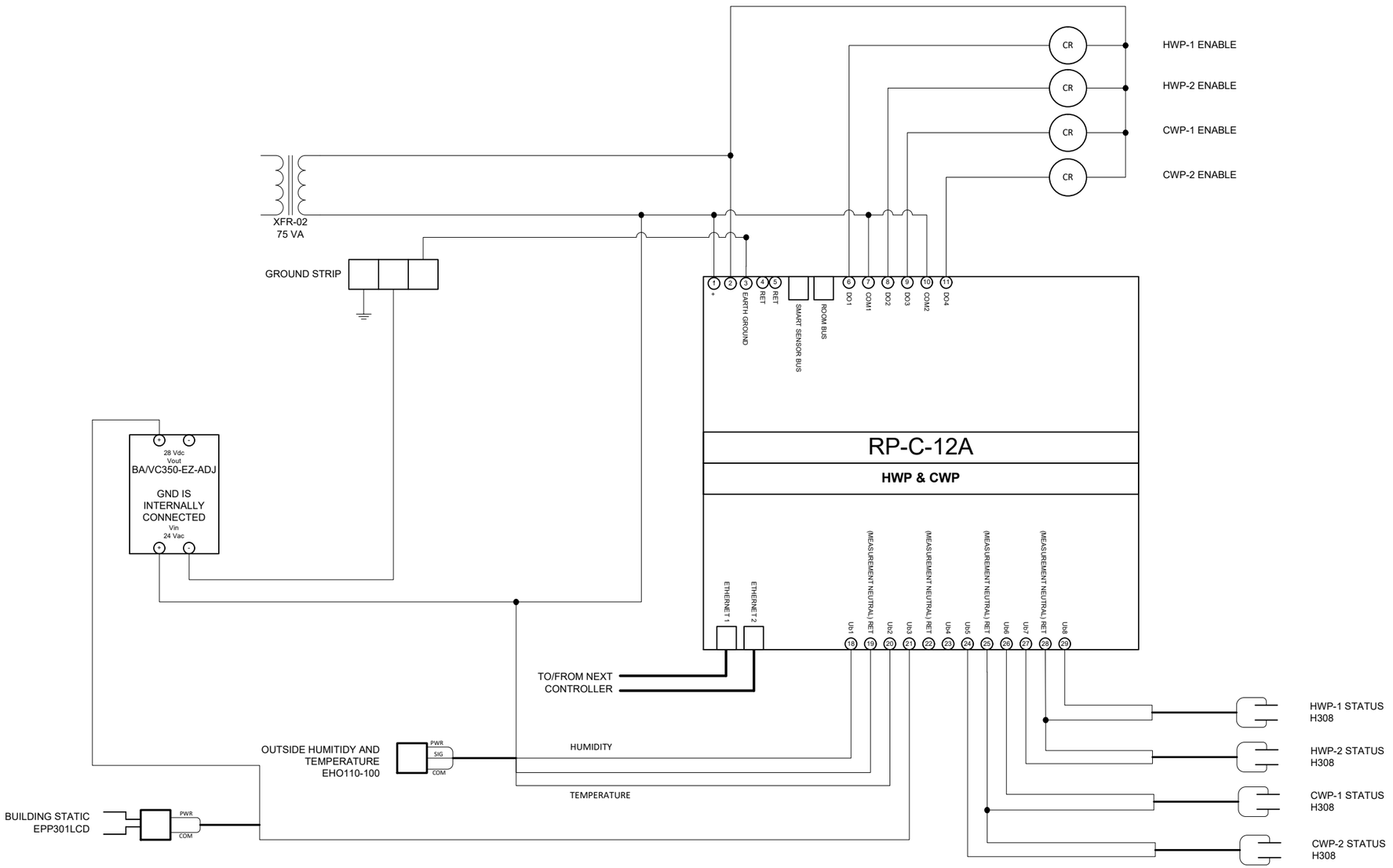

NOTE: BUILDING STATIC PICKUPS ARE EXISTING

TYPICAL OF 1

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BILL OF MATERIALS

QTY	PART NUMBER
1	RP-C-12A
4	H614
1	EHO110
1	ETO200

BY	CHANGE	DATE

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UNIT HEATER SEQUENCE

2. CABINET AND UNIT HEATER CONTROL:

   a. Provide a DDC space temperature thermostat and controller to control modulating control valve to maintain space temperature.

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BILL OF MATERIALS

QTY	PART NUMBER

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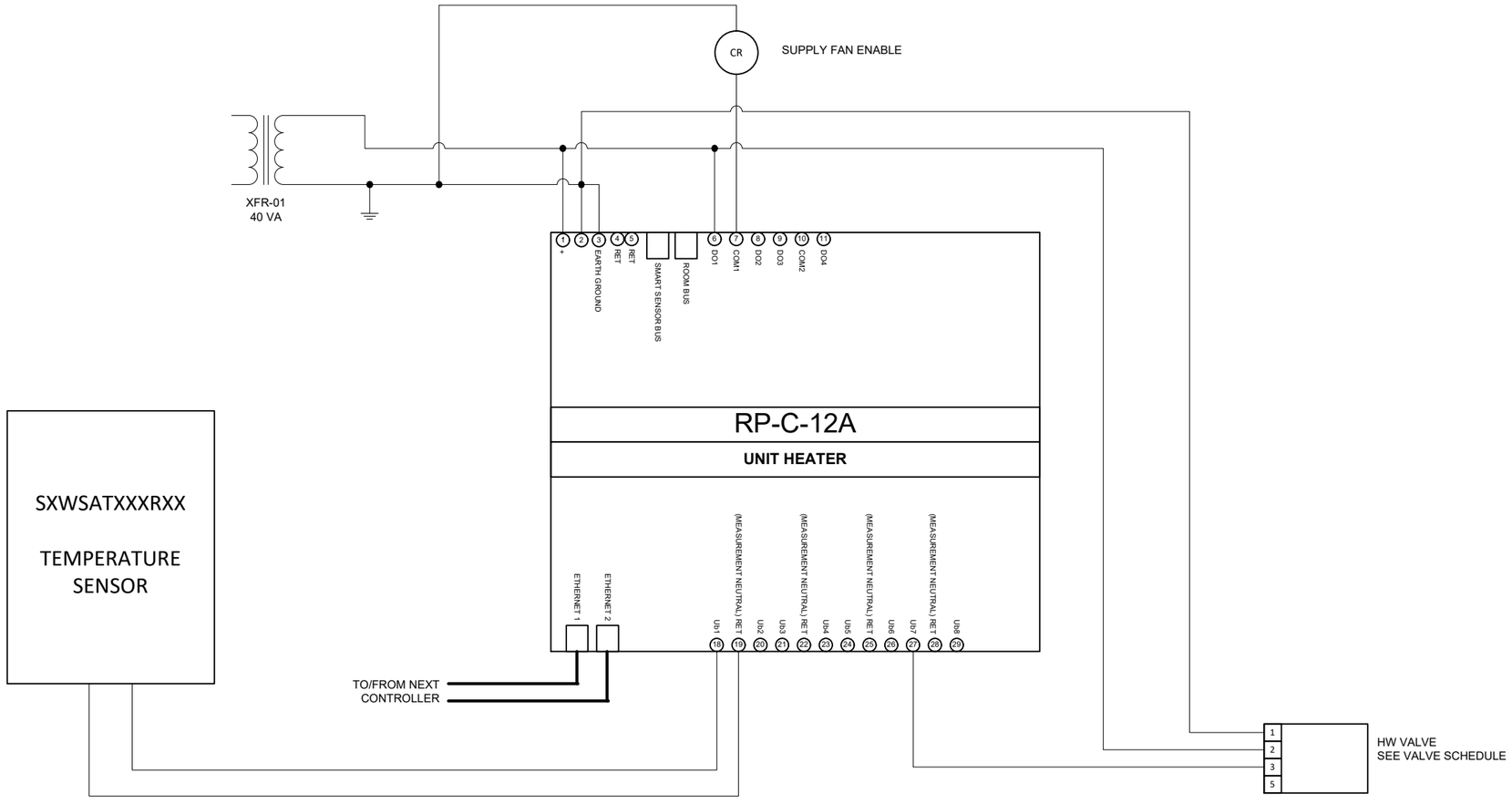

TYPICAL OF 3

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BILL OF MATERIALS

QTY	PART NUMBER
3	RP-C-12
3	SXWXATXXXRXX

BY	CHANGE	DATE

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FAN COIL SEQUENCE

FAN COIL HEATING / COOLING DDC CONTROL:

a. Provide a DDC space temperature thermostat and controller to control modulating control valves for hot water and for chilled water to maintain space temperature. Provide separate heating and cooling setpoints. When the space temperature is below setpoint, the DDC controller shall modulate the chilled water valve closed. When the chilled water valve is fully closed the hot water valve shall modulate open to maintain setpoint. When the space temperature is above setpoint, the DDC controller shall modulate the hot water valve closed. When the hot water valve is fully closed, the chilled water valve shall modulate open to maintain setpoint. Provide DDC start/stop for fan control. Cycle fan on when calling for heating or cooling. When space is satisfied fan shall be off. Provide a discharge temperature for monitoring purposes. The heating and cooling coil valves shall be commanded closed whenever the fan coil fan is off.

FAN COIL HEATING ONLY DDC CONTROL:

a. Provide a DDC space temperature thermostat and controller to control modulating control valve for hot water to maintain space temperature. When the space temperature is below setpoint, the DDC controller shall modulate the hot water valve open to maintain setpoint. The reverse shall occur when space temperature is above setpoint. Provide DDC start/stop for fan control. The fan shall start on a call for heating. When space is satisfied fan shall be off. Provide a discharge temperature for monitoring purposes. The fan coil heating coil valve shall be commanded closed when the fan coil fan is off.

FAN COIL COOLING ONLY DDC CONTROL:

a. Provide a DDC space temperature thermostat and controller to control modulating control valve for chilled water to maintain space temperature. When the space temperature is above setpoint, the DDC controller shall modulate the chilled water valve open to maintain setpoint. The reverse shall occur when space temperature is below setpoint. Provide DDC start/stop for fan control. The fan shall start on a call for cooling. When space is satisfied fan shall be off. Provide a discharge temperature for monitoring purposes. The fan coil cooling coil valve shall be commanded closed when the fan coil fan is off.

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13326 C STREET
OMAHA, NE 68144-3602

402-333-9800 FAX: 402-333-9881

BILL OF MATERIALS

QTY	PART NUMBER

BY	CHANGE	DATE

REVISIONS

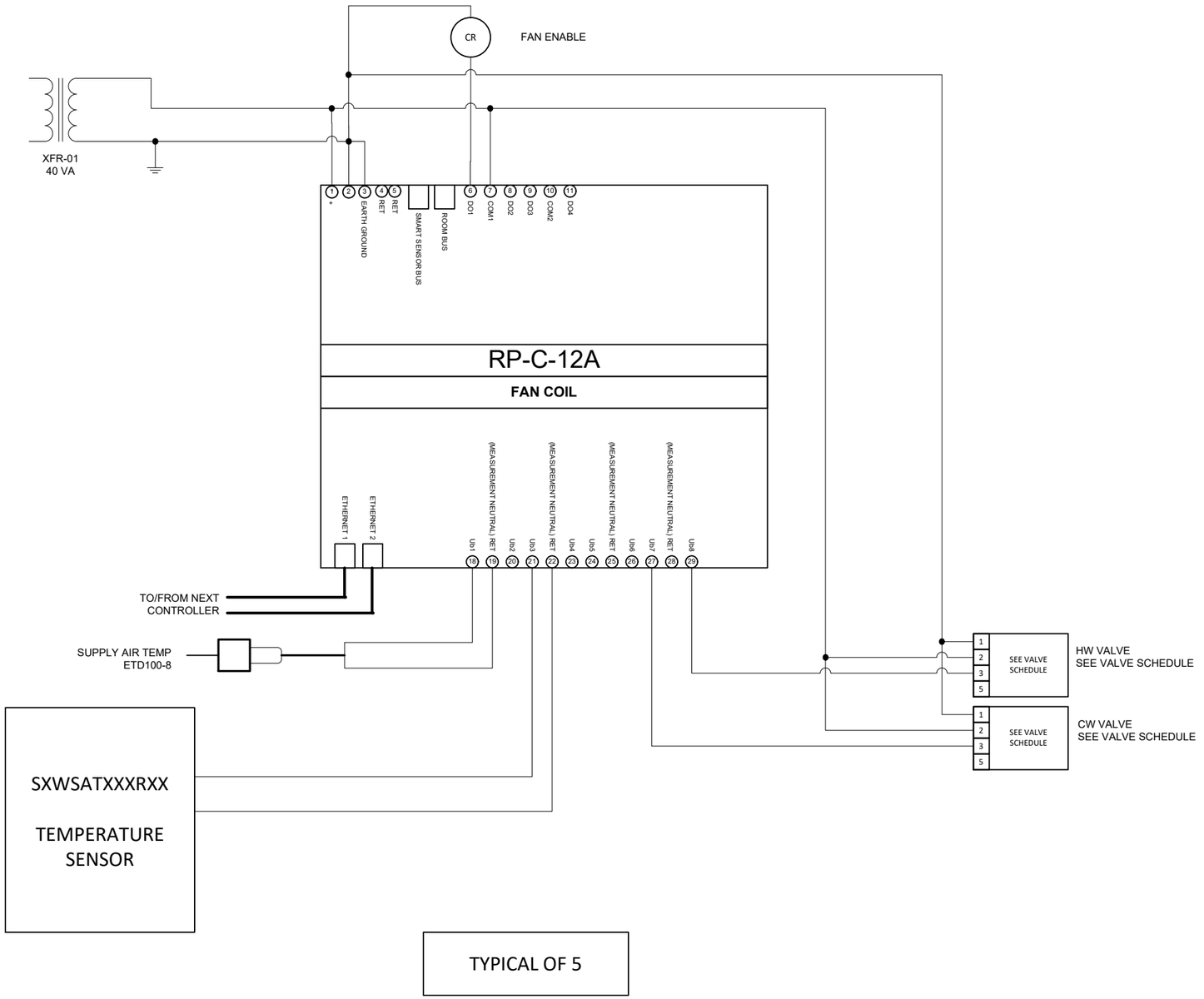
PROJECT: RS21-29 BER

OPS BLACKBURN

DRAWING:

DATE:

6/10/2021



CONTROL MASTERS INC

13326 C STREET
OMAHA, NE 68144-3602

402-333-9800 FAX: 402-333-9881

BILL OF MATERIALS

QTY	PART NUMBER
5	RP-C-12
5	H300
5	SXWSATXXXRXX

BY	CHANGE	DATE

REVISIONS

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6/10/2021

PAGE:

VAV SEQUENCE

VAV TERMINAL UNIT WITH REHEAT DDC CONTROL:

a. Refer to the Air Terminal Schedules on the plans for minimum and maximum flow rates, and CO2 control.

b. Provide a DDC space temperature thermostat and controller to control, in sequence, a modulating electronic control valve for the hot water reheat coil and actuator for terminal air flow. When space temperature is below setpoint, the air terminal damper shall modulate toward the cooling minimum flow position. After the air terminal damper is at its minimum flow, the hot water valve shall modulate open to maintain space temperature. When the space temperature is between the heating and cooling setpoints, the heating valve shall be closed and the supply airflow at heating and cooling minimum flow. The reheat coil valve shall be limited in opening to prevent the discharge air temperature leaving the air terminal from exceeding 95° F (adj.).

c. Radiation Control: For zones with associated radiation, modulate electronic control hot water valve in sequence (simultaneously) with reheat coil to maintain space temperature when associated AHU is running. When space temperature is below setpoint modulate the hot water valve open. The reverse shall occur when space temperature is above setpoint. When the associated AHU is off, the radiation valve shall be modulated to maintain heating setpoint and the associated reheat valve shall be closed. Lock hot water radiation valve closed whenever outside air is above 50° F (adj.).

d. Time of Day Scheduling: Weekly schedule the occupied mode for each zone and/or group by function to reduce the number of schedules required per user agency needs or as specified in the air terminal unit schedules.

e. Grouping of Terminals: Provide a point that can be weekly scheduled for each group. Provide a minimum of one group per ten terminal unit zones (all groups do not need to be used).

f. Airflow Mode Control: In the occupied mode, the zone air terminals shall modulate between the minimum and maximum occupied flow rates as specified in the Air Terminal Schedules. In the standby and unoccupied mode, the zone air terminals shall modulate between 0 CFM flow rate and the maximum occupied flow rate as specified in the Air Terminal Schedules. All airflow setpoints shall be adjustable.

g. Unoccupied/Standby Heating Control with Radiation: If the AHU associated with the VAV terminal is running and the VAV terminal is indexed to unoccupied and has an unoccupied minimum airflow setpoint of zero, the associated radiation terminal shall be used for heating to maintain the unoccupied space temperature heating setpoint and the VAV terminal shall remain closed.

h. Unoccupied/Standby Heating Control without Radiation: If the space temperature falls below the unoccupied zone heating setpoint and the VAV terminal unoccupied airflow setpoint is zero CFM, the VAV terminal shall be indexed to the occupied minimum airflow and the heating valve controlled to maintain the VAV terminal discharge at the discharge air temperature limit control setpoint. When the space temperature rises 2° F (adj.) above the unoccupied space temperature setpoint, the VAV terminal damper and heating valve shall close.

i. Temperature Mode Control: In the occupied mode, the occupied zone temperature heating and cooling setpoints shall be maintained. In the standby mode, the standby zone temperature heating and cooling setpoints shall be maintained. In the unoccupied mode, the unoccupied zone temperature heating and cooling setpoints shall be maintained.

j. Temperature Setpoints: Temperature setpoints listed below shall be the default setpoints, but all setpoints shall be verified and documented with the agency prior to programming the air terminal DDC controllers. For the standby mode, the heating and cooling setpoints shall be 2° F greater and less than the cooling and heating setpoints respectively. For the unoccupied mode, the heating and cooling setpoints shall be 6° F greater and less than the cooling and heating setpoints respectively. All heating and cooling setpoints for each mode shall be adjustable.

Space	Mode	Temp. Setpoint (°F)
Office, Conference, Storage, Lobby, and Classrooms	Cooling	73
	Heating	71
Telecommunication Rooms	Cooling	75
	Heating	65

k. Reset of the AHU outside air ventilation rate by the worst case zone CO2 or return air CO2 value shall also be required if scheduled - see AHU Ventilation sequence.

CONTROL MASTERS INC

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BILL OF MATERIALS

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REVISIONS

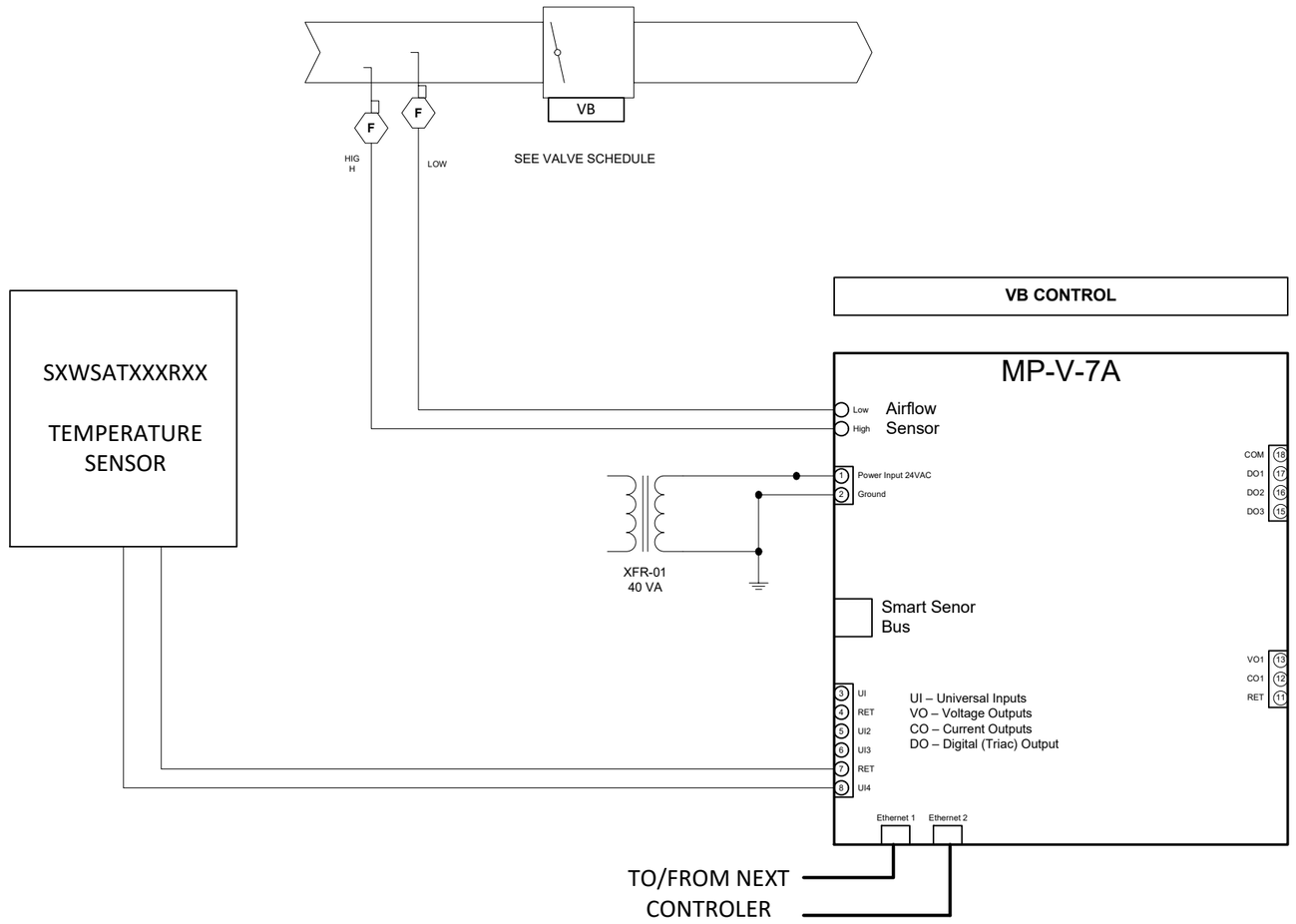
PROJECT: RS21-29 BER

OPS BLACKBURN

DRAWING:

DATE:

6/10/2021



TYPICAL OF 7

CONTROL MASTERS INC

13326 C STREET
OMAHA, NE 68144-3602

402-333-9800 FAX: 402-333-9881

BILL OF MATERIALS

QTY	PART NUMBER
7	MP-V-7A
7	SXWSATXXXRXX

BY	CHANGE	DATE

REVISIONS

PROJECT: RS21-29 | BER

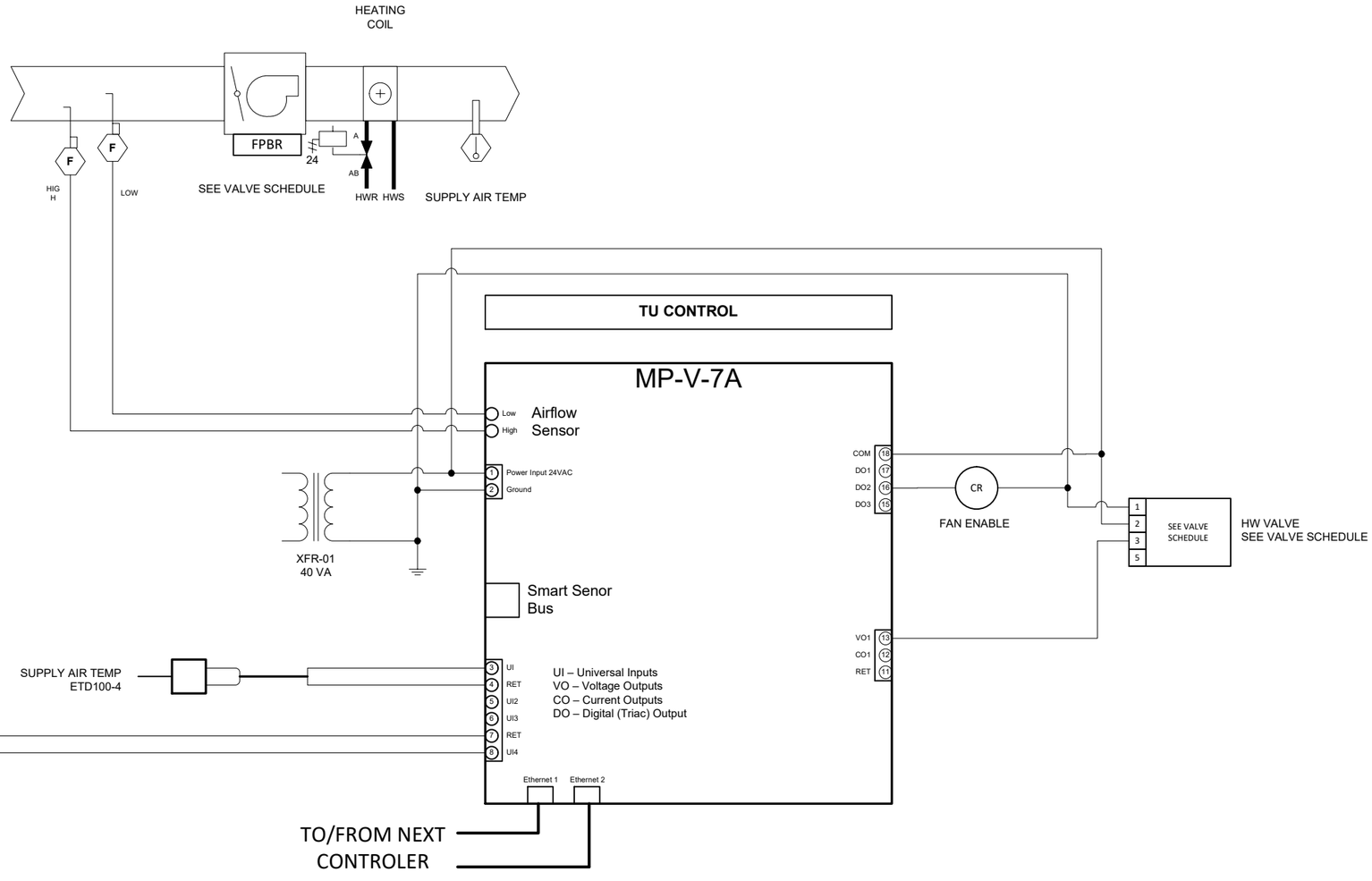
OPS BLACKBURN

DRAWING:

DATE: 6/10/2021

SXWSATXXXRXX

TEMPERATURE SENSOR



TYPICAL OF 6

CONTROL MASTERS INC

13326 C STREET
OMAHA, NE 68144-3602

402-333-9800 FAX: 402-333-9881

BILL OF MATERIALS

QTY	PART NUMBER
6	MP-V-7A
6	SXWSATXXXRXX
6	ETD100-4

BY	CHANGE	DATE

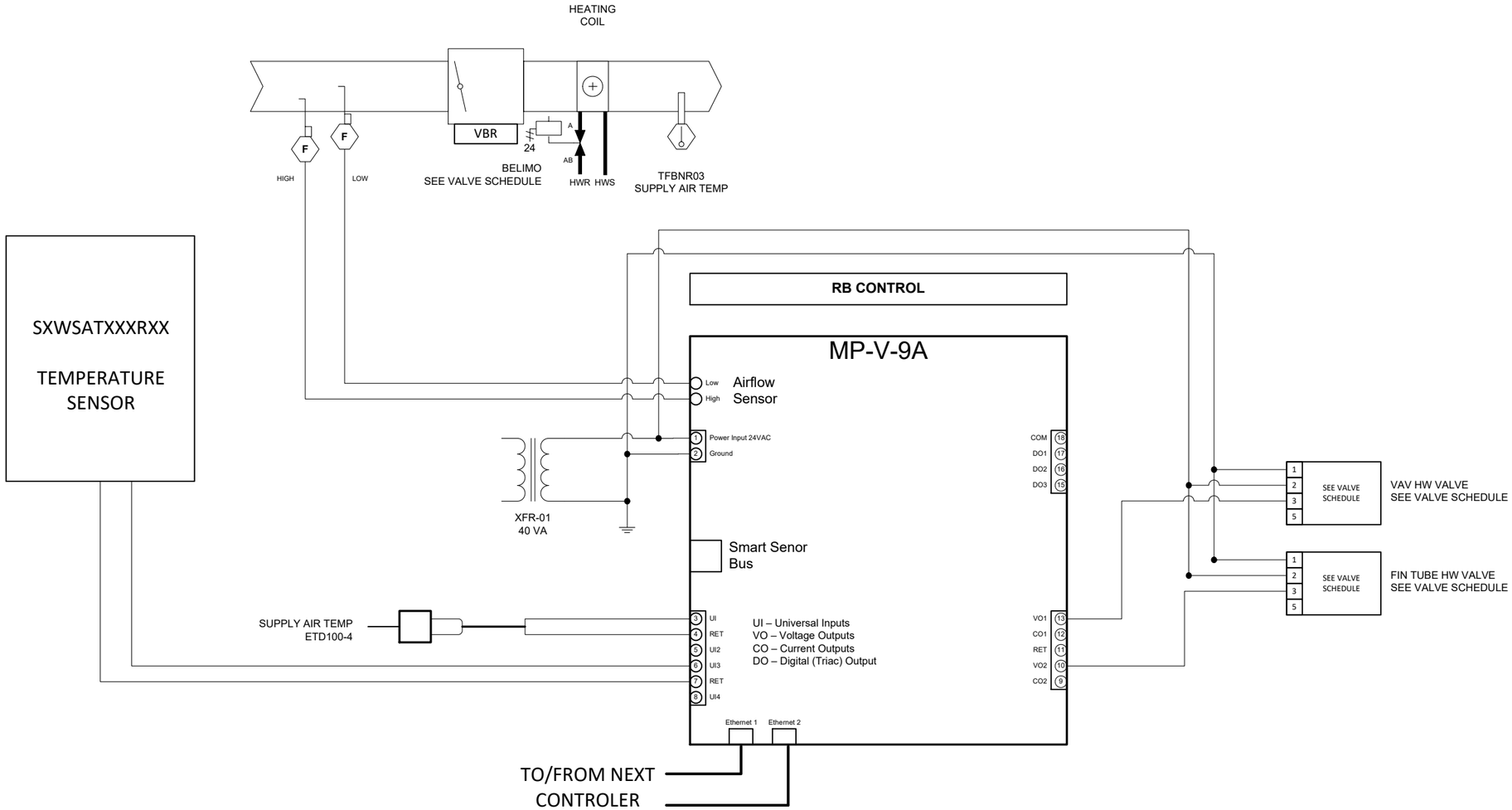
REVISIONS

PROJECT: RS21-29 | BER

OPS BLACKBURN

DRAWING:

DATE: 6/10/2021



*** IF NO FIN TUBE IS PRESENT USE MP-V-7A**

TYPICAL OF 23

CONTROL MASTERS INC

13326 C STREET
OMAHA, NE 68144-3602

402-333-9800 FAX: 402-333-9881

BILL OF MATERIALS

QTY	PART NUMBER
23	MP-V-9A
23	SXWSATXXXRXX
23	ETD100-4

BY	CHANGE	DATE

REVISIONS

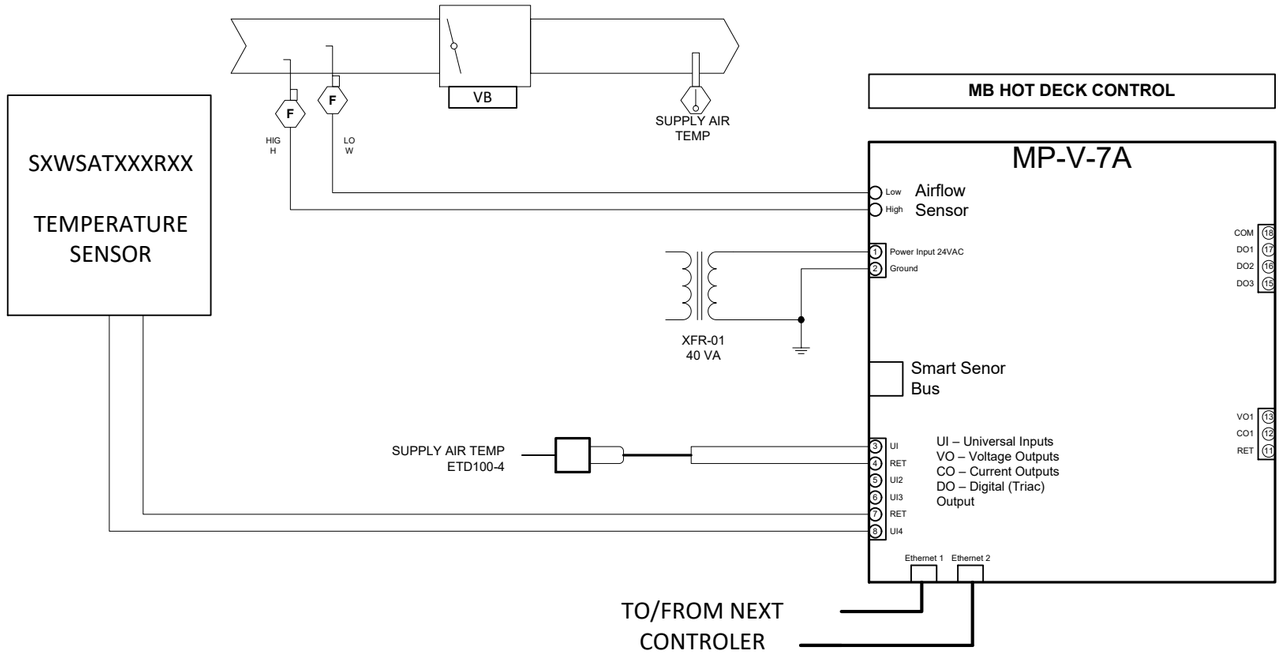
PROJECT: RS21-29 BER

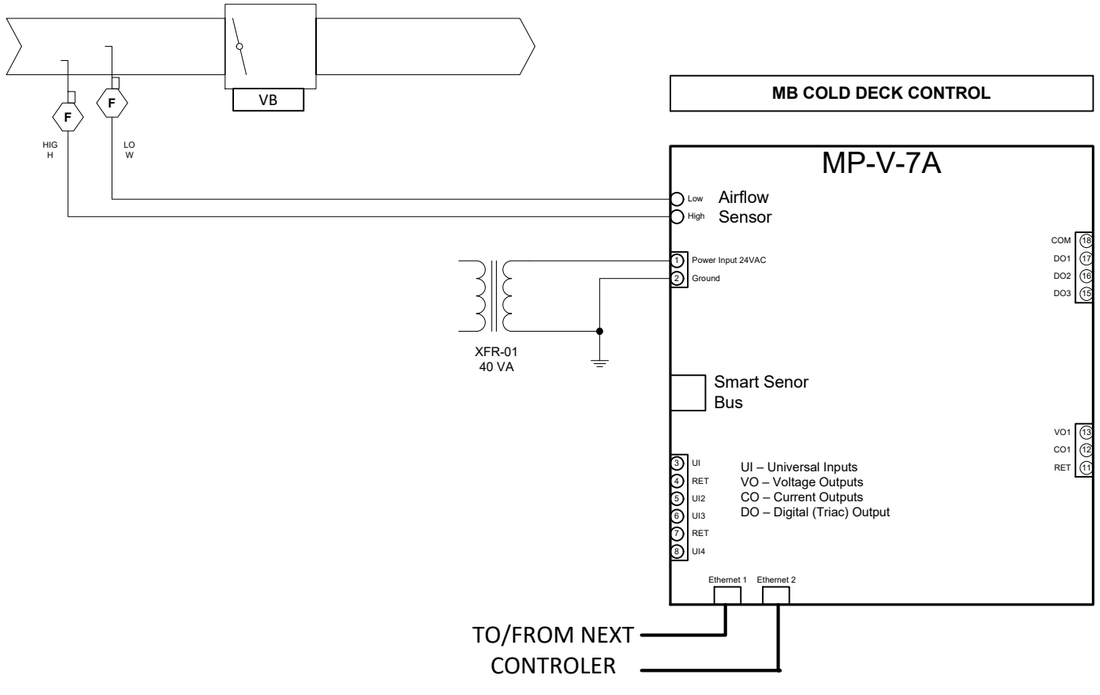
OPS BLACKBURN

DRAWING:

DATE: 6/10/2021

PAGE: 22 OF 26





TYPICAL OF 39

CONTROL MASTERS INC

13326 C STREET
OMAHA, NE 68144-3602

402-333-9800 FAX: 402-333-9881

BILL OF MATERIALS

QTY	PART NUMBER
78	MP-V-7A
39	SXWSATXXXRXX
78	ETD100-4

BY	CHANGE	DATE

REVISIONS

PROJECT: RS21-29 BER

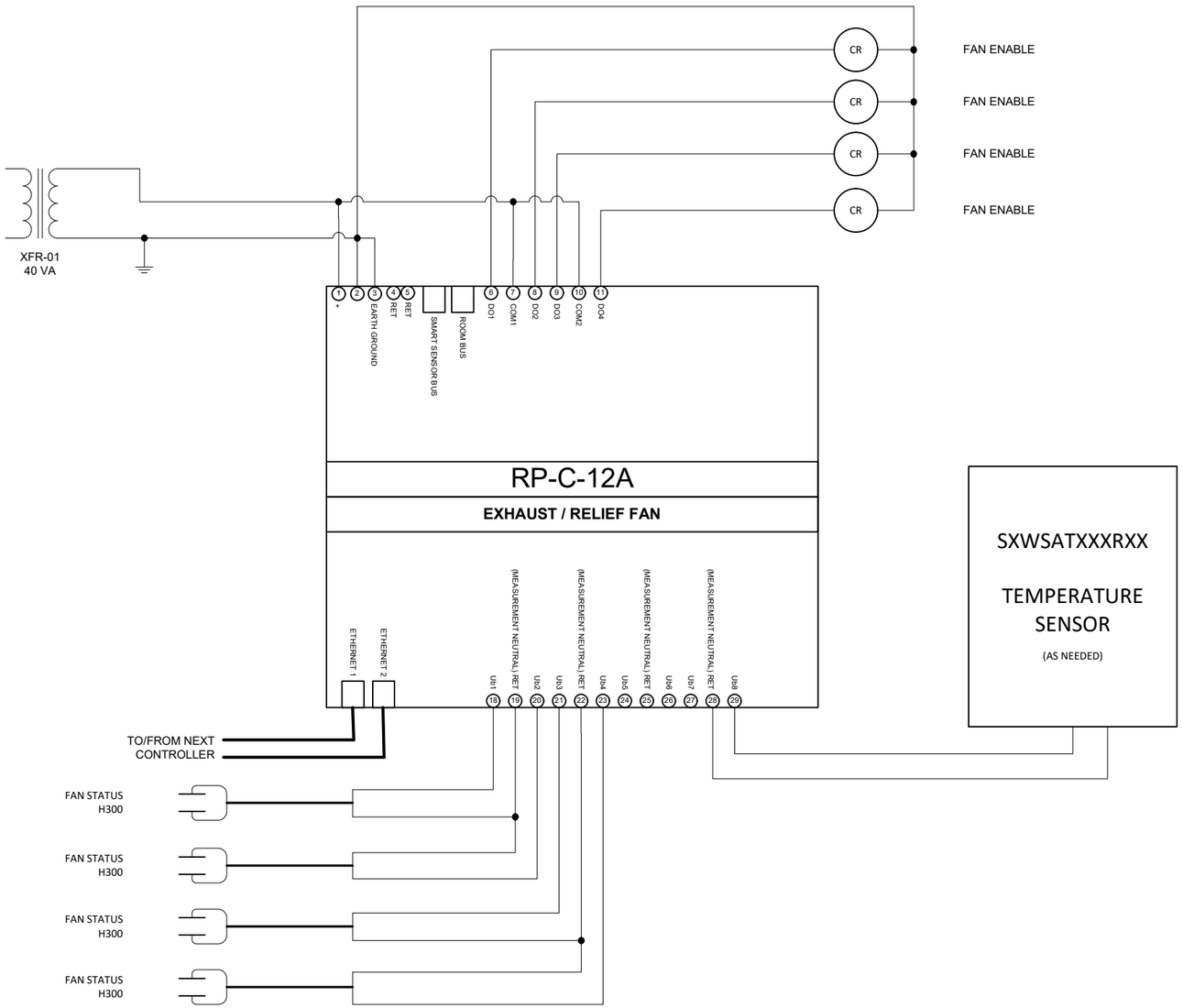
OPS BLACKBURN

DRAWING:

DATE:

6/10/2021

PAGE:



TYPICAL OF 7

CONTROL MASTERS INC

13326 C STREET
OMAHA, NE 68144-3602

402-333-9800 FAX: 402-333-9881

BILL OF MATERIALS

QTY	PART NUMBER
7	RP-C-12
28	H300
1	SXWSATXXXRXX

BY	CHANGE	DATE

REVISIONS

PROJECT: RS21-29 BER

OPS BLACKBURN

DRAWING:

DATE:

6/10/2021

PAGE:

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VALVE SCHEDULE

QTY	SYSTEM	Location	Serves	LINE SIZE IN.	VALVE SIZE IN.	HW/CW	2W OR 3W	GPM	VALVE CV	ADJ. CV	VALVE PD PSI WATER	PART NUMBER	VALVE TYPE
1	Fin Tube	Room 100	Room 100	0.5	0.5	HW	2W	2.4	1.7	1.7	1.99	Z2050Q-J+CQB24-SR-R	Ball
1	Fin Tube	Room 133	Room 133	0.5	0.5	HW	2W	2.4	1.7	1.7	1.99	Z2050Q-J+CQB24-SR-R	Ball
1	Fin Tube	Room 134	Room 134	0.5	0.5	HW	2W	2.4	1.7	1.7	1.99	Z2050Q-J+CQB24-SR-R	Ball
1	Unit Heater	Room 135	Room 135	0.5	0.5	HW	2W	2.4	1.7	1.7	1.99	Z2050Q-J+CQB24-SR-R	Ball
1	Fan Coil	Room 137	Room 137	0.5	0.5	HW	2W	2.4	1.7	1.7	1.99	Z2050Q-J+CQB24-SR-R	Ball
1	Fan Coil	Room 150	Room 150	0.5	0.5	HW	2W	2.4	1.7	1.7	1.99	Z2050Q-J+CQB24-SR-R	Ball
1	Unit Heater	Room 187	Room 187	0.5	0.5	HW	2W	2.4	1.7	1.7	1.99	Z2050Q-J+CQB24-SR-R	Ball
1	Unit Heater	Room 188	Room 188	0.5	0.5	HW	2W	2.4	1.7	1.7	1.99	Z2050Q-J+CQB24-SR-R	Ball
1	Fin Tube	Room 201	Room 201	0.5	0.5	HW	2W	2.4	1.7	1.7	1.99	Z2050Q-J+CQB24-SR-R	Ball
1	Reheat Box	Room 107	Room 107	0.5	0.5	HW	2W	4	2.4	2.4	2.78	Z2050Q-J+CQB24-SR-R	Ball
1	Reheat Box	Room 124	Room 124	0.5	0.5	HW	2W	4	2.4	2.4	2.78	Z2050Q-J+CQB24-SR-R	Ball
1	Fin Tube	Room 332	Room 332	0.5	0.5	HW	2W	4	2.4	2.4	2.78	Z2050Q-J+CQB24-SR-R	Ball
1	Fin Tube	Room 343	Room 343	0.5	0.5	HW	2W	2.4	1.9	1.9	1.60	Z2050Q-J+CQB24-SR-R	Ball
1	Fin Tube	Room 344	Room 344	0.5	0.5	HW	2W	2.4	1.9	1.9	1.60	Z2050Q-J+CQB24-SR-R	Ball
1	Fin Tube	Room 158	Room 158	0.5	0.5	HW	2W	4	2.4	2.4	2.78	Z2050Q-J+CQB24-SR-R	Ball
1	Unit Heater	Room 173	Room 173	0.75	0.5	HW	2W	6	3.3	4.8	1.56	Z2050Q-J+CQB24-SR-R	Ball
1	Unit Heater	Room 191	Room 191	0.75	0.5	HW	2W	8	4.6	4.8	2.78	Z2050Q-J+CQB24-SR-R	Ball
1	Reheat Box	Room 100	Room 100	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball
1	Reheat Box	Room 106	Room 106	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball
1	Reheat Box	Room 107	Room 107	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball
1	Fin Tube	Room 107	Room 107	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball
1	Reheat Box	Room 109	Room 109	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball
1	Reheat Box	Room 111	Room 111	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball
1	Reheat Box	Room 115	Room 115	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball
1	Reheat Box	Room 117	Room 117	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball
1	Reheat Box	Room 118	Room 118	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball
1	Fin Tube	Room 124	Room 124	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball
1	Fin Tube	Room 203	Room 203	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball
1	Reheat Box	Room 204	Room 204	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball
1	Reheat Box	Room 207	Room 207	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball
1	Reheat Box	Room 213	Room 213	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball
1	Reheat Box	Room 219	Room 219	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball
1	Reheat Box	Room 230	Room 230	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball
1	Reheat Box	Room 232	Room 232	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball

CONTROL MASTERS INC

13326 C STREET
OMAHA, NE 68144-3602

402-333-9800 FAX: 402-333-9881

BILL OF MATERIALS

QTY	PART NUMBER

BY	CHANGE	DATE

PROJECT: RS21-29 BER

OPS BLACKBURN

DRAWING:

VALVE SCHEDULE

DATE:

6/10/2021

VALVE SCHEDULE

QTY	SYSTEM	Location	Serves	LINE SIZE IN.	VALVE SIZE IN.	HW/CW	2W OR 3W	GPM	VALVE CV	ADJ. CV	VALVE PD PSI WATER	PART NUMBER	VALVE TYPE
1	Reheat Box	Room 232	Room 232	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball
1	Reheat Box	Room 233	Room 233	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball
1	Reheat Box	Room 235	Room 235	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball
1	Reheat Box	Room 327	Room 327	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball
1	Reheat Box	Room 332	Room 332	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball
1	Reheat Box	Room 332	Room 332	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball
1	Reheat Box	Room 333	Room 333	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball
1	Reheat Box	Room 335	Room 335	0.5	0.5	HW	2W	1	0.7	0.7	2.04	Z2050Q-J+CQB24-SR-R	Ball
41											1.59		
1	AHU 1	M-401	2nd level NE DD MBs	2	1.5	CW	2W	62	35	33.3091	3.38	B240+ARB24-SR	
1	AHU 1	M-401	2nd level NE DD MBs	1.5	1.5	HW	2W	47	29	29	2.63	B239+AFRB24-SR	
1	AHU 2	M-400	2nd level South DD MBs	2	1.5	CW	2W	64	35	33.3091	3.60	B240+ARB24-SR	
1	AHU 2	M-400	2nd level South DD MBs	1.5	1.5	HW	2W	51	29	29	3.09	B239+AFRB24-SR	Ball
1	AHU 3	M-401	Media Center VAV	1.25	0.75	CW	2W	26	24	15.9762	2.65	B221B+LRB24-SR	Ball
1	AHU 3	M-401	Media Center VAV	1	0.75	HW	2W	18	10	5.62009	2.82	B219B+TFRB24-SR	Ball
1	AHU 4	M-400	1st level west VAV	1.25	0.75	CW	2W	29	24	15.9762	3.39	B221B+LRB24-SR	Ball
1	AHU 4	M-400	2nd level west VAV	0.75	0.75	HW	2W	14	10	10	1.96	B219B+TFRB24-SR	Ball
1	AHU 5	M-2-500	Common Areas	2	2	HW	2W	66	46	46	2.06	B249+AFRB24-SR	Ball
1	AHU 5	M-2-500	Common Areas	2.5	2	CW	2W	120	65	63.2028	3.60	B251+ARX24-MFT	Ball
1	AHU 6	M-2-501	Gym	2.5	2	HW	2W	66	46	45.3497	2.12	B249+AFRB24-SR	Ball
1	AHU 6	M-2-501	Gym	2.5	2	CW	2W	120	65	63.2028	3.60	B251+ARX24-MFT	Ball
1	AHU 7	M-2-500	Lecture	1.25	0.75	HW	2W	26	24	15.9762	2.65	B221B+LF24-SR	Ball
1	AHU 7	M-2-500	Lecture	1.25	1	CW	2W	43	30	27.4252	2.46	B225+LRB24	Ball
1	AHU 8	M-2-501	Kitchen Dining	1	0.75	HW	2W	20	14	12.788	2.45	B220+TFRB24-SR	Ball
1	AHU 8	M-2-501	Kitchen Dining	1.25	1	CW	2W	32	19	18.2925	3.06	B224+LR24-SR	Ball
1	AHU 8	M-2-501	Kitchen Dining	0.75	0.5	HW	2W	10	7.4	6.13309	2.66	B214+TFRB-SR	Ball
1	AHU 9	M-2-500	South Class Rooms	1	0.75	HW	2W	14	10	9.52618	2.16	B219B+TFRB24-SR	Ball
1	AHU 9	M-2-500	South Class Rooms	1.25	0.75	CW	2W	29	24	15.9762	3.29	B221B+LRB24-SR	Ball
1	AHU 10	M-508A	Music and Science DD MBs	1.5	1.5	HW	2W	45	29	25	2.41	B239+AFRB24-SR	Ball
1	AHU 10	M-508A	Music and Science DD MBs	1.5	1.5	CW	2W	49	29	29	2.85	B239+ARB24-SR	Ball
1	AHU 11		Womens Locker	1	0.75	HW	2W	13.2	10	9.52618	1.92	B219B+TFRB24-SR	Ball
1	AHU 12		Mens Locker	1	0.75	HW	2W	13.2	10	9.52618	1.92	B219B+TFRB24-SR	Ball
1	AHU 13		Weight Room	1	0.75	HW	2W	14.6	10	9.52618	2.35	B219B+TFRB24-SR	Ball
1	AHU 14		1083 Hallway	1.25	0.75	HW	2W	15.5	10	9.86803	2.93	B219B+TFRB24-SR	Ball
1	AHU 15	2nd level NW	2nd level NW	2	2	CW	2W	62.4	46	46	1.84	B249+ARB24-SR	Ball
1	AHU 2G	Garage	Garage	1	0.75	CW	2W	23	14	12.788	3.24	B220+LRB24-SR	Ball
1	AHU 2G	Garage	Garage	1.25	0.75	HW	2W	15.2	10	9.66003	2.81	B219B+TFRB24-SR	Ball
	RTU 1	Roof	Industrial Tech	1.25	1	CW	3	41	30	27.4252	2.23	B325+LF24-SR	Ball
	RTU 1	Roof	Industrial Tech	2.5	2	HW	3	71	46	45.3497	2.45	B349+AFRB24-SR	Ball

CONTROL MASTERS INC

13326 C STREET
OMAHA, NE 68144-3602

402-333-9800 FAX: 402-333-9881

BILL OF MATERIALS

QTY	PART NUMBER

BER	AHU AND RTU VALVES REVISED	6/9/2021
BY	CHANGE	DATE

PROJECT: RS21-29 BER

OPS BLACKBURN

DRAWING:

VALVE SCHEDULE

DATE:

6/10/2021

13326 "C" Street, Omaha, NE 68144-3602
Telephone: (402) 333-9800 Fax: (402) 333-9881

SECTION 23 09 00:
HVAC INSTRUMENTATION AND CONTROLS

CUTSHEETS

OPS BLACKBURN

JACE® 8000

INTRODUCTION

The JACE 8000 is a compact, embedded IoT (Internet of Things) controller and server platform for connecting multiple and diverse devices and sub-systems. With Internet connectivity and Webserving capability, the JACE 8000 controller provides integrated control, supervision, data logging, alarming, scheduling and network management. It streams data and rich graphical displays to a standard Web browser via an Ethernet or wireless LAN, or remotely over the Internet.

SPECIFICATIONS

SOFTWARE

Compatible with I/A Series G3 3.8 Update 1, Niagara 4.1 or higher

Secure boot

Real-time clock

ELECTRICAL

Power Supply
24 Vac +/-10 %, 50/60 Hz
or 24 Vdc +/-10 %

Battery not required

HARDWARE

CPU
TI AM3352: 1000MHz ARM® Cortex™-A8 processor

Memory
1GB DDR3 SDRAM memory

Removable micro-SD card with 4GB flash total storage and 2GB user storage

Specifications continued on next page.

FEATURES

The licensing model for the JACE 8000 controller is simplified and features standard drivers, as well as optional IO and field bus expansion modules for ultimate flexibility and expandability. The JACE 8000 controller operates with Niagara 4, the latest version of the Niagara Framework®, for optimum performance. In larger facilities, multibuilding applications and large-scale control system integrations, Niagara 4 Supervisors can be used with JACE 8000 controllers to aggregate information, including real-time data, history and alarms, to create a single, unified application.

CONNECTIVITY

The JACE 8000 controller has the following ports and connections:

- Two isolated RS-485 ports
- Two 10/100 Mbit Ethernet ports
- USB type A connector port
- Wi-Fi Configurable radio (Off, WAP, or Client)
- Additional ports and connections are available with the addition of optional expansion modules.

F-27926

July 2016

Specifications continued from first page.

ENVIRONMENT

Operating Temperature
-20 to 60 °C (-4 to 140 °F)

Shipping and Storage Temperature
-40 to 85 °C (-40 to 185 °F)

Humidity
5 to 95 % Non-condensing

Shipping and Vibration
ASTM D4169, Assurance Level II

MTTF
10+ years

AGENCY LISTINGS

US
FCC Part 15 Subpart B, Class B

FCC Part 15 Subpart C

UL 916

Canada
UL listed to Canadian Safety Standards (CAN/CSA 22.2) No. 205-M 1983 “Signaling Equipment”

Radio Standards Specification (RSS)

European Community
CE EN 61326-1

1999/5/EC R&TTE Directive

RoHS

China
CCC

SRRC

COMMUNICATIONS

2 isolated RS-485 ports with selectable bias and termination

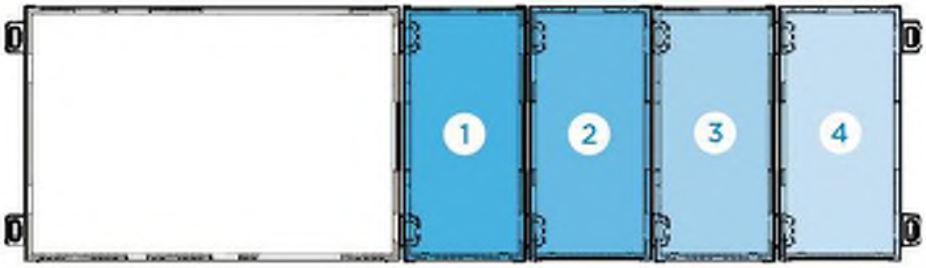
2 10/100 Mbit Ethernet ports

USB type A connector, back-up and restore support

Wi-Fi (Client or WAP)
IEEE802.11a/b/g/n
IEEE802.11n HT20 @ 2.4GHz
IEEE802.11n HT20/HT40 @ 5GHz
Configurable radio (Off, WAP, or Client)
WPAPSK/WPA2PSK supported

OPTIONAL MODULES

Maximum Combinations



Expansion 1	Expansion 2	Expansion 3	Expansion 4
232 or LON	232 or LON	232 or LON	232 or LON
485 x 2	232 or LON	232 or LON	232 or LON
485 x 2	485 x 2	232 or LON	
485 x 2	485 x 2		

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Module Part Numbers

Part Number	Description	Maximum Supported
TRD-NPB-8000-LON	Single-Port LON FTT-10A Expansion Module	4
TRD-NPB-8000-232	Single-Port Electrically Isolated RS-232 Expansion Module	4
TRD-NPB-8000-2X-485	Dual-Port Electrically Isolated RS-485 Expansion Module	2
TRD-IO-16-485	Remote IO Module with RS-485	16

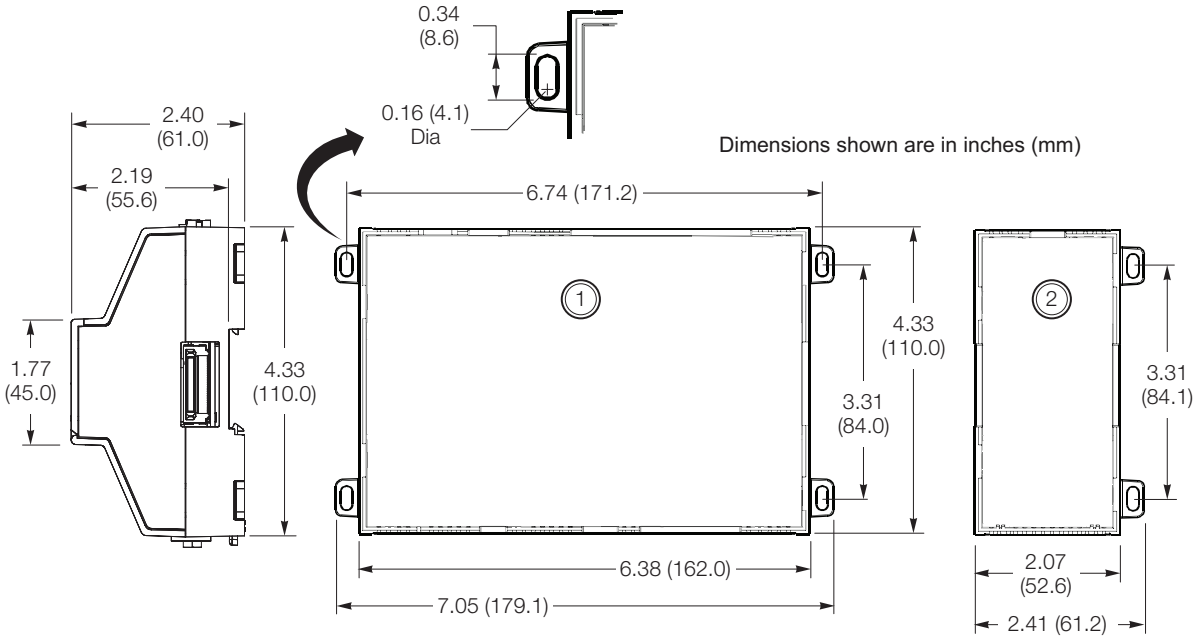
MODELS

Part Number	Description
TRD-JACE-8000	Base unit includes two isolated RS485 ports, two 10/100MB Ethernet ports, USB Backup and Restore, and Wi-Fi connectivity.
TRD-JACE-8000-DEMO	Base unit includes two isolated RS485 ports, two 10/100MB Ethernet ports, USB Backup and Restore, Wi-Fi connectivity, all available standard drivers, and a 500 device license. Hardware accessories purchased separately.
TRD-NC-8005	Up to 5 devices/250 point core.
TRD-NC-8010	Up to 10 devices/500 point core.
TRD-NC-8025	Up to 25 devices/1,250 point core.
TRD-NC-8100	Up to 100 devices/5,000 point core.
TRD-NC-8200	Up to 200 devices/10,000 point core.
TRD-DEVICE-10	Up to 10 devices/500 point upgrade (can be purchased during initial licensing).
TRD-DEVICE-25	Up to 25 devices/1,250 point upgrade (can be purchased during initial licensing).
TRD-DEVICE-50	Up to 50 devices/2,500 point upgrade (can be purchased during initial licensing).
TRD-DEVICE-UP-10	Up to 10 devices/500 point upgrade (can be purchased post initial licensing).
TRD-DEVICE-UP-25	Up to 25 devices/1,250 point upgrade (can be purchased post initial licensing).
TRD-DEVICE-UP-50	Up to 50 devices/2,500 point upgrade (can be purchased post initial licensing).
TRD-JACE-8000-AX	Enables JACE® 8000 controller to run Niagara AX (3.8U1). 3.8U1 Build with JACE 8000 controller support.
TRD-NPB-8000-2X-485	Add-on dual-port electrically isolated RS-485 expansion module for JACE 8000 controller.
TRD-NPB-8000-LON	Add-on single-port LON FTT-10A expansion module for JACE 8000 controller.
TRD-NPB-8000-232	Add-on single-port electrically isolated RS-232 expansion module for JACE 8000 controller.
TRD-WPM-8000	Universal power supply for JACE 8000 controller.

Part Number	Description
TRD-IO-16-485	Remote IO module, compatible with the JACE 8000 controller. Communication using RS 485, maximum IO supported by T-IO-16-485 modules: 16.
TRD-NPB-PWR	24V power supply for T-IO-16-485.
TRD-NPB-PWR-UN	Universal power supply for T-IO-16-485.

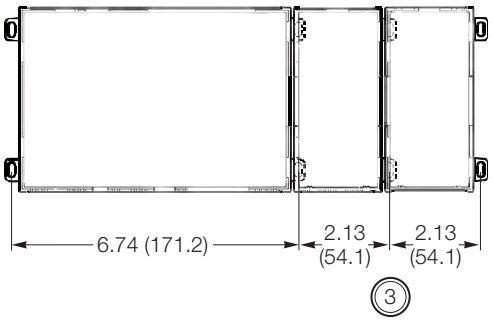
*All TRD-NC-8xxx parts include a Niagara 4 license and the standard driver suite.

MOUNTING DIMENSIONS



Compatible with (DIN43880) enclosures.
Suitable for mounting to a panel or to an EN50022 standard 35mm rail.

1. JACE 8000 controller. Allow at least 1.5" (38 mm) clearance around all sides and minimum 3" (76 mm) clearance at bottom for Wi-Fi antenna.
2. Expansion module. Up to four may be used. See "Optional Modules".
3. Distances measured between center of tabs from one unit to adjacent unit.



powered by niagara framework®

AS-P

Introduction

At the core of a SmartStruxure solution is a SmartStruxure server device, such as AS-P. AS-P performs key functionality, such as control logic, trend logging, and alarm supervision, and supports communication and connectivity to the I/O and field buses. The distributed intelligence of the SmartStruxure solution ensures fault tolerance in the system and provides a fully featured user interface through WorkStation and WebStation.

Features

AS-P is a powerful device that can act as a standalone server and also control I/O modules and monitor and manage field bus devices. In a small installation, the embedded AS-P device acts as a standalone server, mounted with its I/O modules in a small footprint. In medium and large installations, functionality is distributed over multiple SmartStruxure server devices that communicate over TCP/IP.

Communications hub

Capable of coordinating traffic from above and below its location, AS-P can deliver data directly to you or to other servers throughout the site. AS-P can run multiple control programs, manage local I/O, alarms, and users, handle scheduling and logging, and communicate using a variety of protocols. Because of this, most parts of the system function autonomously and continue to run as a whole even if communication fails or individual SmartStruxure servers or devices go offline.

Variety of connectivity options

AS-P has numerous ports that enable it to communicate with a wide range of protocols, devices, and servers.

AS-P has the following ports:

- Two 10/100 Ethernet ports
- Two RS-485 ports
- One LonWorks TP/FT port
- One built-in I/O bus port
- One USB host port
- One USB device port

The USB device port allows you to upgrade and interact with AS-P using Device Administrator. The USB host port can be used to provide power and communications for the AD touchscreen display.

The two Ethernet ports are connected to a built-in Ethernet switch. One port should be connected to the site network. The other port can be used to connect a single WorkStation or WebStation, a Modbus TCP unit, or a BACnet/IP device, but not another SmartStruxure server.

Authentication and permissions

A SmartStruxure solution provides a powerful permission system that is easy to manage, flexible, and adapts to all kinds of system sizes. The permission system provides a security level to the highest standards. Authentication is done against the built-in user account management system or against Windows Active Directory Domains. The built-in account management system allows an administrator to set password policies that meet stringent CyberSecurity guidelines. When Windows Active Directory is used, the administration costs are lower because users do not have to be managed in multiple directories.

WorkStation/WebStation interface

Through any client, the user experience is similar regardless of which SmartStruxure server the user is logged on to. The user can log directly on to AS-P to engineer, commission, supervise, and monitor AS-P as well as its attached I/O modules and field bus devices. See the WorkStation and WebStation datasheets for additional information.

Open building protocol support

One of the cornerstones of SmartStruxure solution is support for open standards. AS-P can natively communicate with three of the most popular standards for buildings: BACnet, LonWorks, and Modbus.

Native BTL-listed BACnet support

AS-P communicates directly to BACnet/IP and BACnet MS/TP networks. AS-P is BTL-listed as a BACnet Building Controller (B-BC), the most advanced BACnet Device Profile. This capability provides access to an extensive range of BACnet devices from Schneider Electric and other vendors. See the BTL Product Catalog for up-to-date details on BTL listed firmware revisions on BACnet International's home page. AS-P can also serve as a BACnet Broadcast Management Device (BBMD) to facilitate BACnet systems that span multiple IP networks.

Native LonWorks support

AS-P has a built-in FTT-10 port to communicate to the TP/FT-10 LonWorks network. Integrated LonWorks functionality enables access to LonWorks devices from Schneider Electric and other vendors. LonWorks networks can be commissioned, bound, and configured from AS-P using the built-in LonWorks Network Management Tool. No third-party tools are needed. A protocol analyzer with powerful debugging and network quality monitoring features can be achieved using third-party software, without additional hardware needed. To increase ease of use, LNS device plug-ins are supported. This allows for easier engineering and maintenance of LonWorks devices from Schneider Electric and other vendors. There are some limitations on how LNS device plug-ins can be used.

Native Modbus support

AS-P natively integrates Modbus RS-485 master and slave configurations, as well as TCP client and server. This allows full access to third-party products and the range of Schneider Electric products that communicate on the Modbus protocol, such as power meters, UPS, circuit breakers, and lighting controllers.

Additional building protocol support

AS-P also supports integration and communication with Schneider Electric supplied BMS systems and devices that use the following standards for buildings: I/NET, MicroNet, NETWORK 8000, and Andover Continuum Infinet.

Web Services support

AS-P supports the use of Web Services based on open standards, such as SOAP and REST, to consume data into the SmartStruxure solution. Use incoming third-party data (temperature forecast, energy cost) over the Web to determine site modes, scheduling, and programming.

EcoStruxure Web Services support

EcoStruxure Web Services, Schneider Electric's Web Services standard, is natively supported in AS-P. EcoStruxure Web Services offers extra features between compliant systems whether within Schneider Electric or other authorized systems. These features include system directory browsing, read/write of current values, alarm receipt and acknowledgement, and historical trend log data. EcoStruxure Web Services is secure. User name and password are required to log on to the system.

Scalable custom configurations

AS-P and its family of I/O modules were designed to meet the unique needs of each installation. Depending on the configuration, each AS-P can control up to 464 I/O points. Because power and communications are delivered along a common bus, multiple modules can be plugged together without tools in a simple one-step process using the built-in connectors.

Two programming options

Unique to the industry, AS-P has both Script and Function Block programming options. This flexibility assures that the best programming method can be selected for the application.

03-19031-02-en April 2017

4 GB of eMMC memory for data and backup

AS-P has an available capacity of 4 GB of eMMC memory. This represents 2 GB for application and historical data and 2 GB dedicated for backup storage. This ensures that all data is safe from damage, loss, or unintended edits. Users can also manually back up or restore AS-P to a storage location on a PC or network. Through the Enterprise Server, users have the ability to perform scheduled backups of associated AS-P devices to network storage for even greater levels of protection.

IT friendly

AS-P communicates using the networking standards. This makes installations easy, management simple, and transactions secure.

TLS support

Communication between clients and the SmartStruxure servers can be encrypted using Transport Layer Security (TLS 1.2). The servers are delivered with a default self-signed certificate. Commercial Certification Authority (CA) server certificates are supported to lower the risk of malicious information technology attacks. Use of encrypted communication can be enforced for both WorkStation and WebStation access.

Supported protocols

- IP addressing (IPv6 ready)
- TCP communications
- DHCP/DNS for rapid deployment and lookup of addresses
- HTTP/HTTPS for Internet access through firewalls, which enables remote monitoring and control
- NTP (Network Time Protocol) for time synchronization throughout the system
- SMTP or SMTPS with support for SSL/TLS based authentication, enables sending email messages triggered by schedule or alarm
- SNMP enables network supervision and reception of application alarms in designated network management tools

Patented two-piece design

Each module can be separated from its terminal base to allow the site to be wired prior to the installation of the electronics. The patented locking mechanism serves as handles for removing the module from its base. All critical components have a protective cover that permits convection cooling to occur.

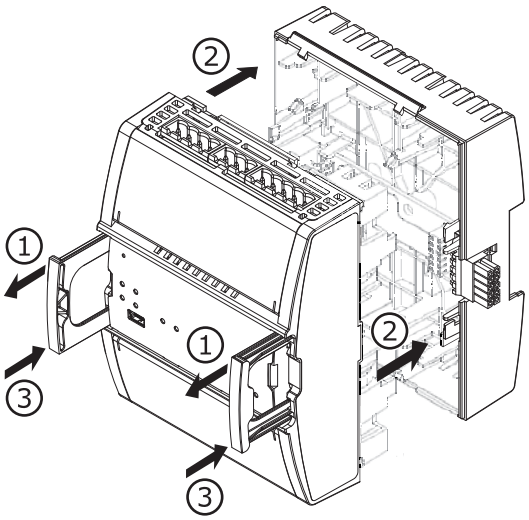


Figure: Two-piece design

Auto-addressing

The auto-addressing feature eliminates the need for setting DIP switches or pressing commission buttons. Each module automatically knows its order in the chain and assigns itself accordingly – significantly reducing engineering and maintenance time.

Simple DIN-rail installation

Fasteners easily snap into a locked position for panel installation. The fastener has a quick-release feature for easy DIN-rail removal.

Specifications

Electrical

DC input supply power ..... 10 W

DC input supply voltage .....24 VDC

Environment

Ambient temperature, operating .....0 to 50 °C (32 to 122 °F)

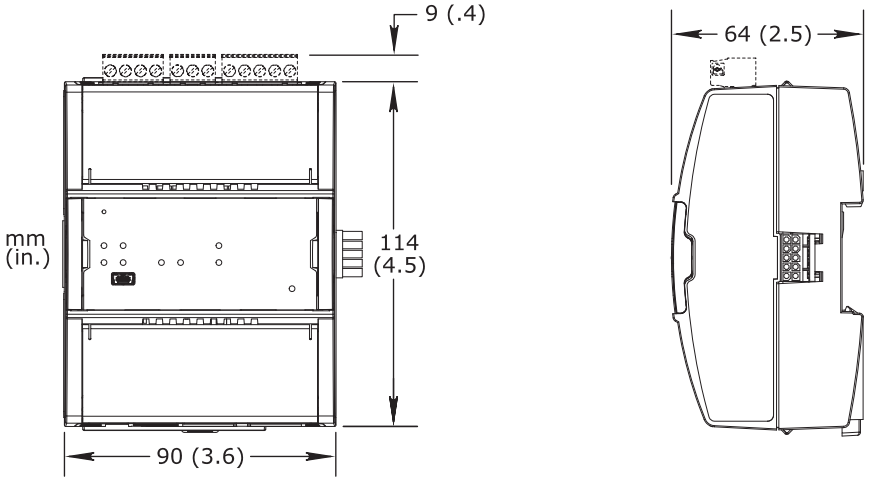
Ambient temperature, storage .....-20 to +70 °C (-4 to +158 °F)
Maximum humidity.....95 % RH non-condensing

Material

Plastic rating.....UL94-5VB
Enclosure .....PC/ABS
Enclosure rating.....IP 20

Mechanical

Dimensions including terminal base .....90 W x 114 H x 64 D mm (3.6 W x 4.5 H x 2.5 D in.)



Weight including terminal base..... 0.321 kg (0.71 lb)
Weight excluding terminal base..... 0.245 kg (0.54 lb)

Agency compliances

Emission .....RCM; EN 61000-6-3; EN 50491-5-2; FCC Part 15, Sub-part B, Class B
Immunity .....EN 61000-6-2; EN 50491-5-3
Safety.....EN 60730-1; EN 60730-2-11; EN 50491-3; UL 916 C-UL US Listed
Product .....EN 50491-1
Smoke control product safety[a, b] .....UL 864

a) Applies to AS-P for Smoke Control (AS-P-SMK) and AS-P Terminal Base (TB-ASP-W1).
b) AS-P for Smoke Control (AS-P-SMK) is shipped with a validated UL 864 software version, which can differ from the latest released software. For more information, see Smoke Control Design Guide for UL 864.

Real-time clock backup

Inaccuracy, at 25 °C (77 °F).....+/-52 seconds per month
Backup time .....10 days

Communication ports

Ethernet ..... Dual 10/100BASE-TX RJ45
USB..... USB 2.0, 1 device port (mini-B) and 1 host port (type-A)
RS-485 .....Dual 2-wire ports, bias 5.0 VDC
LonWorks TP/FT-10

Communications

BACnet.....BACnet/IP and MS/TP, port configurable, default 47808

.....BTL B-BC (BACnet Building Controller)[a]

a) See the BTL Product Catalog for up-to-date details on BTL listed firmware revisions on BACnet International's home page.

Modbus .....Modbus TCP, client and server
.....Serial, RS-485, master or slave

TCP .....Binary, port fixed, 4444

HTTP.....Non-binary, port configurable, default 80

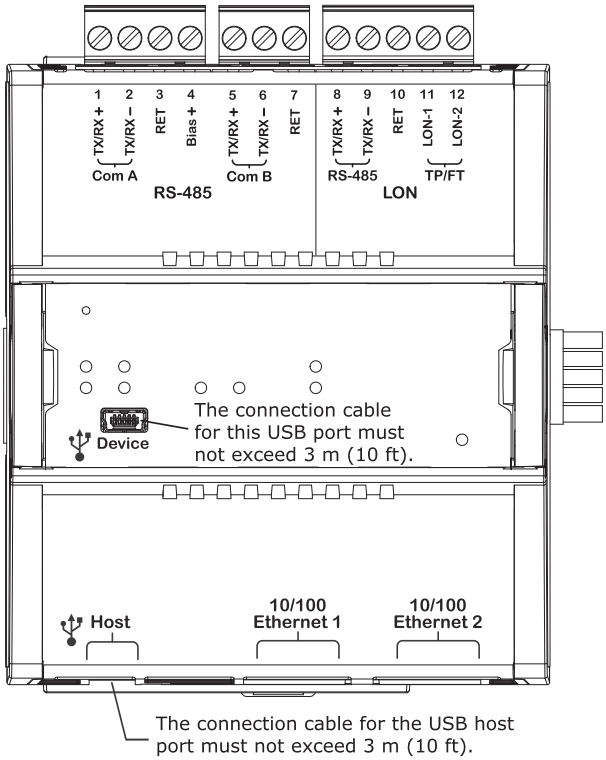
HTTPS.....Encrypted supporting TLS 1.2, 1.1, and 1.0, port configurable default 443

SMTP.....Email sending, port configurable, default 25

SMTPS .....Email sending, port configurable, default 587

SNMP.....version 3
..... Network supervision using poll and trap
.....Application alarm distribution using trap

Terminals



LNS

LNS version..... OpenLNS
.....Installed on WorkStation PC

LonMark

Resource files version 14.00

CPU

Frequency ..... 500 MHz

Type.....SPEAr1380, ARM Cortex-A9 dual-core

DDR3 SDRAM..... 512 MB

eMMC memory .....4 GB

Memory backup ..... Yes, battery-free, no maintenance

Part numbers

SmartX Controller – AS-P SXWASPXXX10001

SmartX Controller – AS-P-SMK[a].....SXWASPXXX1S001
a) AS-P for Smoke Control (AS-P-SMK) is shipped with a validated UL 864 software version, which can differ from the latest released software. For more information, see Smoke Control Design Guide for UL 864.

TB-ASP-W1, Terminal Base for SmartX Controller – AS-P
(Required for each SmartX Controller – AS-P)..... SXWTBASW110002

Add-on options

SW-EWS-1, EcoStruxure Web Services (run-time) option
Consume only for one SmartStruxure server, no maintenance.....SXWSWEWSX00001

SW-EWS-2, EcoStruxure Web Services (run-time) option
Serve & Consume for one SmartStruxure server, no maintenance SXWSWEWSX00002

SW-EWS-3, EcoStruxure Web Services (run-time) option
Serve & Consume, plus Historical trend log data for one SmartStruxure server, no maintenance SXWSWEWSX00003

SW-GWS-1, Web Services (Generic Consume) option
For one SmartStruxure server, no maintenance SXWSWGWSX00001

SW-SNMP-1, Alarm notifications via SNMP option
For one SmartStruxure server, no maintenance.....SXWSWSNMP00001

SW-SMARTDRIVER-1, Communication to external devices via SmartDriver
For one SmartDriver license.....SXWSWSDRV00001

Regulatory Notices

Federal Communications Commission
FCC Rules and Regulations CFR 47, Part 15, Class B
This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference. (2) This device must accept any interference received, including interference that may cause undesired operation.

Industry Canada
This Class B digital apparatus complies with Canadian ICES-003.
Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

Regulatory Compliance Mark (RCM) - Australian Communications and Media Authority (ACMA)
This equipment complies with the requirements of the relevant ACMA standards made under the Radiocommunications Act 1992 and the Telecommunications Act 1997. These standards are referenced in notices made under section 182 of the Radiocommunications Act and 407 of the Telecommunications Act.

CE - Compliance to European Union (EU)
2014/30/EU Electromagnetic Compatibility Directive
2011/65/EU Restriction of Hazardous Substances (RoHS) Directive
This equipment complies with the rules, of the Official Journal of the European Union, for governing the Self Declaration of the CE Marking for the European Union as specified in the above directive(s) per the provisions of the following standards: EN 50491-1 Product Standard; EN 60730-1, EN 60730-2-11, and EN 50491-3 Safety Standards.

WEEE - Directive of the European Union (EU)
This equipment and its packaging carry the waste of electrical and electronic equipment (WEEE) label, in compliance with European Union (EU) Directive 2012/19/EU, governing the disposal and recycling of electrical and electronic equipment in the European community.

UL 916 Listed products for the United States and Canada, Open Class Energy Management Equipment. UL file E80146.

UL 864 Listed products for the United States. 10th Edition Smoke Control System. UL file S5527.

MP-C

SmartX IP Controller

Introduction

SmartX IP Controller – MP-C is a multi-purpose, fully programmable, IP based field controller. The MP-C models offer a flexible mix of I/O point types that suit a wide range of HVAC applications. MP-C can either be used as a standalone BACnet/IP field controller or as part of an EcoStruxure BMS with a SmartX AS-P or AS-B server or an Enterprise Server as the parent server. The MP-C models support an optional display that provides insight and control of the inputs and outputs.

The MP-C has the following features:

- IP enabled with dual port Ethernet switch
- Versatile onboard I/O point mix
- High reliability
- Sensor bus for living space sensors
- Mobile commissioning application
- Full EcoStruxure Building Operation software support, providing efficient engineering tools

IP connectivity and flexible network topologies

The MP Series controllers are based on open protocols that simplify interoperability, IP configuration, and device management:

- IP addressing
- BACnet/IP communications
- DHCP for easy network configuration

The MP Series controllers have a dual-port Ethernet switch, which enables flexible network topologies:

- Star
- Daisy chain
- Rapid Spanning Tree Protocol (RSTP) ring

In a star topology, the controller and the parent EcoStruxure BMS server are individually connected to an Ethernet switch. You can reduce the installation time and cost by daisy-chaining multiple controllers together. You can use an RSTP ring topology when you want failures of a single controller to be detected and recovered quickly and efficiently.

Models with a versatile mix of I/O points

MP-C comes in five models with different I/O point count and a versatile mix of I/O point types that match a wide variety of applications. Most of the I/O points are universal inputs/outputs, which are highly flexible and can be configured as either inputs or outputs.

03-20035-01-en, May 2018

MP-C

SmartX IP Controller

I/O Point Types by MP-C Models

I/O Point Types	MP-C-15A	MP-C-18A	MP-C-18B	MP-C-24A	MP-C-36A
Universal I/O Type Ub	8	10	10	16	20
Universal I/O Type Uc	-	-	-	4	8
Triac outputs	6	4	8	-	-
Relay outputs Form A	-	3	-	4	8
High power relay outputs Form A	1	1	-	-	-

Configurations by I/O Point Types

Configurations	Universal I/O Type Ub	Universal I/O Type Uc	Triac Outputs	Relay Outputs Form A	High Power Relay Outputs Form A
Digital inputs	yes	yes	-	-	-
Counter inputs	yes	yes	-	-	-
Supervised inputs	yes	yes	-	-	-
Voltage inputs (0 to 10 VDC)	yes	yes	-	-	-
Current inputs (0 to 20 mA)	yes	yes	-	-	-
Temperature inputs	yes	yes	-	-	-
Resistive inputs	yes	yes	-	-	-
2-wire RTD temperature inputs	yes	yes	-	-	-
Voltage outputs (0 to 10 VDC)	yes	yes	-	-	-
Current outputs (0 to 20 mA)	-	yes	-	-	-
Digital outputs	-	-	yes	yes	yes
Digital pulsed outputs	-	-	yes	yes	yes
PWM outputs	-	-	yes	yes[a]	yes[a]
Tristate outputs	-	-	yes	yes	-
Tristate pulsed outputs	-	-	yes	yes	-

a) Not suitable as Pulse Width Modulated (PWM) outputs.

03-20035-01-en, May 2018

MP-C

SmartX IP Controller

Universal inputs/outputs

The universal inputs/outputs are ideal for any mix of temperature, pressure, flow, status points, and similar point types in a building control system.

As counter inputs, the universal inputs/outputs are commonly used in energy metering applications. As RTD inputs, they are ideal for temperature points in a building control system. As supervised inputs, they are used for security applications where it is critical to know whether or not a wire has been cut or shorted. These events provide a separate indication of alarms and trouble conditions to the system.

For all analog inputs, maximum and minimum levels can be defined to automatically detect over-range and under-range values.

The universal inputs/outputs can also be used as voltage outputs or current outputs (Uc only), without the need for external bias resistors. Therefore, the universal inputs/outputs support a wide range of devices, such as actuators.

Triac outputs

The triac outputs can be used in many applications to switch 24 VAC on or off for external loads such as actuators, relays, or indicators. The triac outputs are isolated from the controller. Triacs are silent and do not suffer from relay contact wear.

Relay outputs

The relay outputs support digital Form A point types. The Form A relays are designed for direct load applications.

High power relay output

MP-C-15A and MP-C-18A have a high power relay output, which is ideal for switching loads of up to 12 A, such as electrical heating elements.

High reliability

The MP Series controllers support local trends, schedules, and alarms, enabling local operation when the controller is offline or used in standalone applications.

The battery-free power backup of the memory and real-time clock prevents data loss and ensures seamless and quick recovery after a power failure.

All MP-C models can be equipped with the MP-C Display add-on module, which features an LCD display and five keys. With this module, you can manually override analog and digital outputs for testing, commissioning, and maintenance of equipment connected to the outputs. The module's dedicated processing power ensures reliable override for maintenance applications. The override status is readable through EcoStruxure Building Operation WorkStation and WebStation, enabling precise monitoring and reliable control.

MP-C Display

WorkStation allows you to update the firmware of multiple MP Series controllers at the same time and with minimum down time. The EcoStruxure BMS server keeps track of the installed firmware to support backup, restore, and replacement of the controllers and sensors. The server can host controllers of different firmware versions.

Sensor bus for living space sensors

The MP Series controllers provide an interface designed for the SmartX Sensor family of living space sensors. The SmartX Sensors offer an efficient way to sense the temperature, humidity, CO_2, and occupancy in a room. The SmartX Sensors are available with different combinations of sensor types and various covers and user interface options, such as touchscreen, setpoint and override buttons, and blank covers.

03-20035-01-en, May 2018

MP-C

SmartX IP Controller

SmartX Sensors

The sensor bus provides both power and communications for up to four sensors that are daisy-chained using standard Cat 5 (or higher) cables. The maximum number of sensors that can be connected to a controller varies depending on the sensor model and the combination of cover and sensor base type:

- Blank covers: Up to four sensors of any combination of sensor base types
- 3-button and touchscreen covers:
  - Up to two sensor bases with CO_2 option
  - Up to four sensor bases without CO_2 option
- SmartX LCD temperature sensors: Up to four sensors are supported

The maximum total length of the sensor bus is 61 m (200 ft). For more information, see the SmartX Living Space Sensors Specification Sheet.

Mobile commissioning application

The eCommission SmartX Controllers mobile application is designed for local configuration, field deployment, and commissioning of MP Series controllers. The mobile application reduces the commissioning time, allows flexibility in project execution, and eliminates dependencies on network infrastructure.

The mobile application is designed for use with Android, Apple (iOS), and Microsoft Windows 10 devices. For more information, see the eCommission SmartX Controllers Specification Sheet.

eCommission SmartX Controllers mobile app

Using the eCommission SmartX Controllers mobile application, you can connect to one or many MP Series controllers. You can connect to a single MP Series controller using the eCommission Bluetooth Adapter connected to a SmartX Sensor. You can connect to a network of MP Series controllers on the local IP network, using a wireless access point or a network switch.

Device configuration

With the eCommission SmartX Controllers mobile application, you can easily discover MP Series controllers on the IP network and change each controller's configuration, including the BACnet and IP network settings, location, and parent server. To save engineering time, you can save common device settings and then reuse them for controllers of the same model.

Field deployment and I/O checkout

The eCommission SmartX Controllers mobile application does not require an EcoStruxure BMS server or a network infrastructure to be in place. You can use the mobile application to load the controller application directly into the local MP Series controller and deploy the controller. The controller application can be created offline using Project Configuration Tool or WorkStation. You can also perform an I/O checkout to ensure that the controller's I/O points are configured, wired, and operating correctly.

03-20035-01-en, May 2018

MP-C

SmartX IP Controller

Full EcoStruxure Building Operation software support

The power of the MP Series controller is fully realized when it is part of an EcoStruxure BMS, which provides the following benefits:

- WorkStation/WebStation interface
- Script and Function Block programming options
- Device discovery
- Engineering efficiency

WorkStation/WebStation interface

WorkStation and WebStation provide a consistent user experience regardless of which EcoStruxure BMS server the user is logged on to. The user can log on to the parent EcoStruxure BMS server to engineer, commission, supervise, and monitor the MP Series controller and its I/O as well as its attached SmartX Sensors. For more information, see the WorkStation and WebStation specification sheets.

Script and Function Block programming options

Unique to the industry, the MP Series controllers have both Script and Function Block programming options. This flexibility assures that the best programming method can be selected for the application. Existing programs can easily be reused between the EcoStruxure BMS server and the controller.

Device discovery

The enhanced Device Discovery in WorkStation enables you to easily identify MP Series controllers on a BACnet network and to associate the controllers with their parent server.

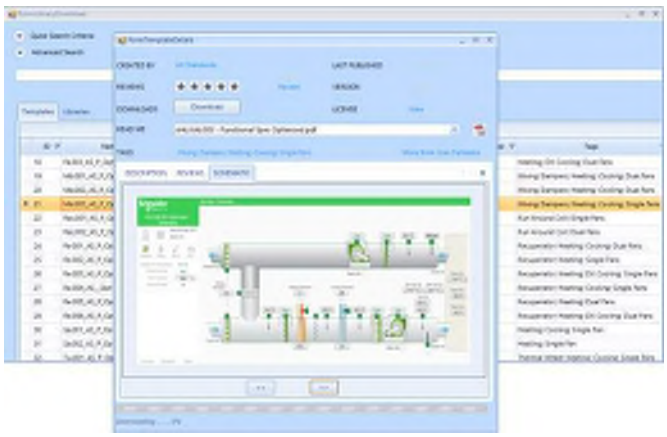
Engineering efficiency

The engineering and maintenance of MP Series controllers can be done very efficiently using the EcoStruxure Building Operation reusability features. With these features, you can create library items (Custom Types) for a complete controller application that contains programs and all necessary objects such as trends, alarms, and schedules. The controller application in the Custom Types library is reusable across all controllers of the same model. You can use the controller application as a base for creating new controllers intended for similar applications. You can then edit the controller application, and the changes are automatically replicated to all controllers, while each controller keeps its local values.

WorkStation supports both online and offline engineering of MP Series controllers. You can make the configuration changes online or use database mode to make the changes offline. In database mode, the changes are saved to the EcoStruxure Building Operation database so that you can apply the changes to the controllers later.

Project Configuration Tool enables you to perform all the engineering off site, without the need for physical hardware, which minimizes the time you need to spend on site. You can run the EcoStruxure BMS servers virtually and engineer the MP Series controllers, before you deploy your server and controller applications to the servers and controllers on site. For more information, see the Project Configuration Tool specification sheet.

In addition, you can use Automated Engineering Tool to facilitate your engineering process when using MP Series controllers. This tool provides access to a library of standard controller applications. These standard applications can be quickly configured and customized using the wizards and mass edit functions provided in the tool and then loaded into your target server. The tool also enables the quick creation of your own templates based on MP Series controller applications that you have developed. This facilitates a standard approach and drives the ability to easily reuse and duplicate common controller applications. For more information, see the Automated Engineering Tool specification sheet.



Library of standard HVAC applications

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MP-C

SmartX IP Controller

Part Numbers

Product	Part number
MP-C-15A	SXWMPC15A10001
MP-C-18A	SXWMPC18A10001
MP-C-18B	SXWMPC18B10001
MP-C-24A	SXWMPC24A10001
MP-C-36A	SXWMPC36A10001
MP-C DISPLAY (MP-C override display module)	SXWMPCDSP10001
Spare terminal blocks for all MP-C models (4 x 3-pin, 1 x 4-pin, 7 x 6-pin, 2 x 8-pin terminal blocks)	SXWMPCCON10001
DIN-RAIL-CLIP, DIN-rail end clip package of 25 pieces	SXWDINEND10001
eCommission Bluetooth Adapter	SXWBTAECXX10001

Specifications

AC input

Nominal voltage ..... 24 VAC
Operating voltage range ..... +/-20 %
Frequency ..... 50/60 Hz
Maximum power consumption (MP-C-15A, -18A, -18B) ..... 22 VA
Maximum power consumption (MP-C-24A) ..... 28 VA
Maximum power consumption (MP-C-36A) ..... 33 VA
Power input protection ..... MOV suppression and internal fuse

DC input

Nominal voltage ..... 24 to 30 VDC
Operating voltage range ..... 21 to 33 VDC
Maximum power consumption (MP-C-15A, -18A, -18B) ..... 12 W
Maximum power consumption (MP-C-24A) ..... 15 W
Maximum power consumption (MP-C-36A) ..... 18 W
Power input protection ..... MOV suppression and internal fuse

Environment

Ambient temperature, operating ..... 0 to 50 °C (32 to 122 °F) at normal operation[a]
..... -40 to +60 °C (-40 to +140 °F) for rooftop applications, horizontal installation only[a]
a) MP-C Display has an operating temperature range of -30 to +60 °C (-22 to +140 °F).
Ambient temperature, storage ..... -40 to +70 °C (-40 to +158 °F)
Maximum humidity ..... 95 % RH non-condensing

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MP-C

SmartX IP Controller

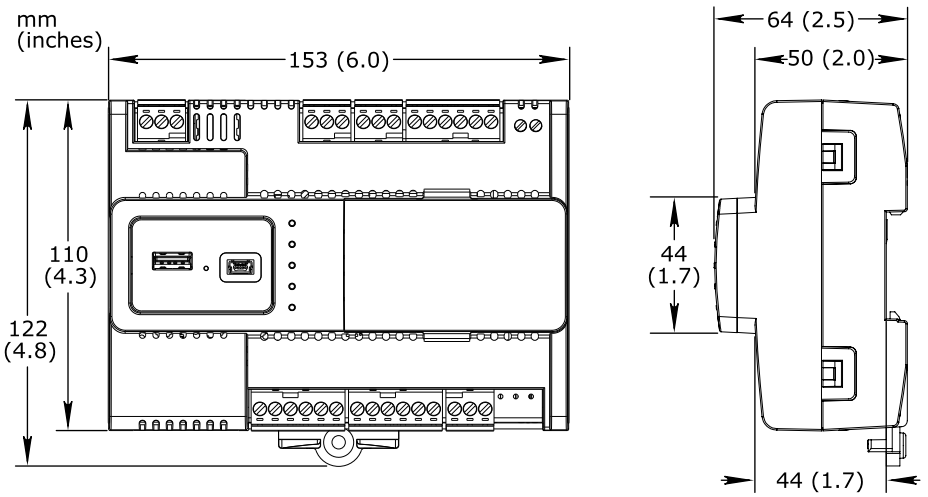
Material

Plastic flame rating UL94-5V

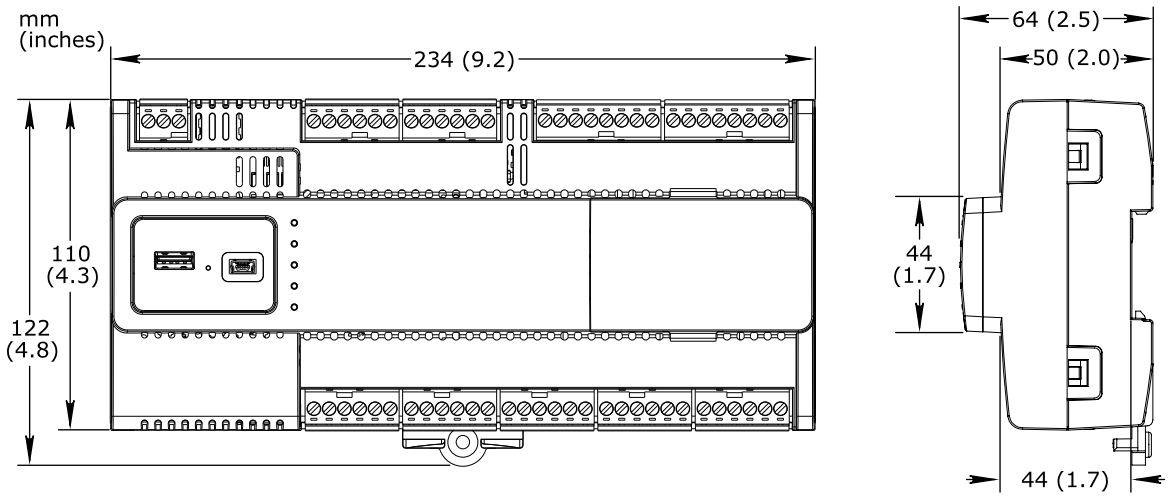
Ingress protection rating ..... IP 20

Mechanical

Dimensions (MP-C-15A, -18A, -18B) ..... 153 W x 110 H x 64 D mm (6.0 W x 4.3 H x 2.5 D in.)



Dimensions (MP-C-24A, -36A) ..... 234 W x 110 H x 64 D mm (9.2 W x 4.3 H x 2.5 D in.)



Weight, MP-C-15A
Including terminal blocks ..... 0.358 kg (0.789 lb)

Weight, MP-C-18A
Including terminal blocks ..... 0.371 kg (0.818 lb)

Weight, MP-C-18B
Including terminal blocks ..... 0.361 kg (0.796 lb)

Weight, MP-C-24A
Including terminal blocks ..... 0.495 kg (1.091 lb)

Weight, MP-C-36A
Including terminal blocks ..... 0.547 kg (1.206 lb)

MP-C

SmartX IP Controller

Installation.....DIN rail or other flat surface inside a cabinet
Terminal blocks .....Removable

Software compliance

EcoStruxure Building Operation software .....version 2.0 or later

Agency compliances

Emission.....RCM; EN 61000-6-3; EN 50491-5-2; FCC Part 15, Sub-part B, Class B
Immunity .....EN 61000-6-2; EN 50491-5-3
Safety .....EN 60730-1; EN 60730-2-11; EN 50491-3; UL 916 C-UL US Listed

Real-time clock

Accuracy, at 25 °C (77 °F) .....+/-1 minute per month
Backup time, at 25 °C (77 °F) .....7 days minimum

Communication ports

Ethernet ..... Dual 10/100BASE-TX (RJ45)
USB ..... USB 2.0, 5 VDC, 2.5 W, 1 device port (mini-B) and 1 host port (type-A)
Sensor Bus .....24 VDC, 2 W, RS-485 (RJ45)
Sensor Bus protection .....Transient voltage suppressors on communication and power signals

Communications

BACnet.....BACnet/IP, port configurable, default 47808
.....BTL B-AAC (BACnet Advanced Application Controller)[a]

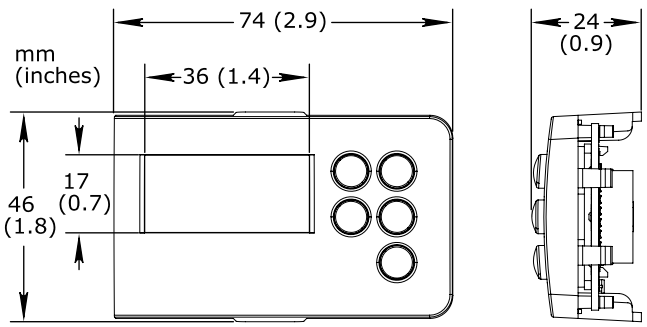
a) See the BTL Product Catalog for up-to-date details on BTL listed firmware revisions on BACnet International's home page.

CPU

Frequency ..... 500 MHz
Type.....ARM Cortex-A7 dual-core
DDR3 SDRAM .....128 MB
NOR flash memory .....32 MB
Memory backup.....128 kB, FRAM, non-volatile

MP-C Display (Optional)

Removable .....No
Dimensions .....74 W x 46 H x 24 D mm (2.9 W x 1.8 H x 0.9 D in.)



MP-C

SmartX IP Controller

Display size ..... 36 W x 17 H mm (1.4 W x 0.7 H in.)
Display resolution ..... 128 x 64 pixels
Display type ..... FSTN monochrome LCD, white color transflective backlight
Power consumption ..... max. 0.15 W (45 mA at 3.3 V)
Ambient temperature, operating ..... -30 to +60 °C (-22 to +140 °F)
Ambient temperature, storage ..... -40 to +70 °C (-40 to +158 °F)
Maximum humidity ..... 95 % RH non-condensing
Weight ..... 0.035 kg (0.077 lb)
Compliance with standards ..... EN ISO 16484-2

Universal inputs/outputs, Ub and Uc

Channels, MP-C-15A ..... 8 Ub, Ub1–Ub8
Channels, MP-C-18A ..... 10 Ub, Ub1–Ub10
Channels, MP-C-18B ..... 10 Ub, Ub1–Ub10
Channels, MP-C-24A ..... 16 Ub, Ub1–Ub16
..... 4 Uc, Uc1–Uc4
Channels, MP-C-36A ..... 20 Ub, Ub1–Ub20
..... 8 Uc, Uc1–Uc8
Absolute maximum ratings ..... -0.5 to +24 VDC
A/D converter resolution ..... 16 bits
Universal input/output protection ..... Transient voltage suppressor on each universal input/output

Digital inputs

Range ..... Dry contact switch closure or open collector/open drain, 24 VDC, typical wetting current 2.4 mA
Minimum pulse width ..... 150 ms

Counter inputs

Range ..... Dry contact switch closure or open collector/open drain, 24 VDC, typical wetting current 2.4 mA
Minimum pulse width ..... 20 ms
Maximum frequency ..... 25 Hz

Supervised inputs

5 V circuit, 1 or 2 resistors
Monitored switch combinations ..... Series only, parallel only, and series and parallel
Resistor range ..... 1 to 10 kohm
For a 2-resistor configuration, each resistor must have the same value +/- 5 %

Voltage inputs

Range ..... 0 to 10 VDC
Accuracy ..... +/-(7 mV + 0.2 % of reading)
Resolution ..... 1.0 mV
Impedance ..... 100 kohm

Current inputs

Range ..... 0 to 20 mA

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MP-C

SmartX IP Controller

Accuracy.....+/-(0.01 mA + 0.4 % of reading)
Resolution.....1 µA
Impedance .....47 ohm

Resistive inputs

10 ohm to 10 kohm accuracy .....+/-(7 + 4 x 10^{-3} x R) ohm
R = Resistance in ohm

10 kohm to 60 kohm accuracy .....+/-(4 x 10^{-3} x R + 7 x 10^{-8} x R^2) ohm
R = Resistance in ohm

Temperature inputs (thermistors)

Range.....-50 to +150 °C (-58 to +302 °F)

Supported thermistors

Honeywell .....20 kohm
Type I (Continuum) .....10 kohm
Type II (I/NET) .....10 kohm
Type III (Satchwell) .....10 kohm
Type IV (FD) ..... 10 kohm
Type V (FD w/ 11k shunt) .....Linearized 10 kohm
Satchwell D?T.....Linearized 10 kohm
Johnson Controls .....2.2 kohm
Xenta.....1.8 kohm
Balco.....1 kohm

Measurement accuracy

20 kohm.....-50 to -30 °C: +/-1.5 °C (-58 to -22 °F: +/-2.7 °F)
.....-30 to 0 °C: +/-0.5 °C (-22 to +32 °F: +/-0.9 °F)
..... 0 to 100 °C: +/-0.2 °C (32 to 212 °F: +/-0.4 °F)
.....100 to 150 °C: +/-0.5 °C (212 to 302 °F: +/-0.9 °F)

10 kohm, 2.2 kohm, and 1.8 kohm.....-50 to -30 °C: +/-0.75 °C (-58 to -22 °F: +/-1.35 °F)
.....-30 to +100 °C: +/-0.2 °C (-22 to +212 °F: +/-0.4 °F)
.....100 to 150 °C: +/-0.5 °C (212 to 302 °F: +/-0.9 °F)

Linearized 10 kohm .....-50 to -30 °C: +/-2.0 °C (-58 to -22 °F: +/-3.6 °F)
.....-30 to 0 °C: +/-0.75 °C (-22 to +32 °F: +/-1.35 °F)
..... 0 to 100 °C: +/-0.2 °C (32 to 212 °F: +/-0.4 °F)
.....100 to 150 °C: +/-0.5 °C (212 to 302 °F: +/-0.9 °F)

1 kohm .....-50 to +150 °C: +/-1.0 °C (-58 to +302° F: +/-1.8 °F)

RTD temperature inputs

Supported RTDs.....Pt1000

Pt1000

Sensor range.....-50 to +150 °C (-58 to +302 °F)

Controller environment	Sensor range	Measurement accuracy
0 to 50 °C (32 to 122 °F)	-50 to +70 °C (-58 to +158 °F)	+/-0.5 °C (+/-0.9 °F)

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MP-C

SmartX IP Controller

Continued

Controller environment	Sensor range	Measurement accuracy
0 to 50 °C (32 to 122 °F)	70 to 150 °C (158 to 302 °F)	+/-0.7 °C (+/-1.3 °F)
-40 to +60 °C (-40 to +140 °F)	-50 to +150 °C (-58 to +302 °F)	+/-1.0 °C (+/-1.8 °F)

RTD temperature wiring

Maximum wire resistance.....20 ohm/wire (40 ohm total)

Maximum wire capacitance.....60 nF
The wire resistance and capacitance typically corresponds to a 200 m wire.

Voltage outputs

Range.....0 to 10 VDC

Accuracy.....+/-60 mV

Resolution.....10 mV

Minimum load resistance.....5 kohm

Load range.....-1 to +2 mA

Current outputs (Uc only)

Range.....0 to 20 mA

Accuracy.....+/-0.2 mA

Resolution.....21 µA

Load range.....0 to 650 ohm

Relay outputs, DO

Channels, MP-C-15A.....0

Channels, MP-C-18A.....3, DO5–DO7

Channels, MP-C-18B.....0

Channels, MP-C-24A.....4, DO1–DO4

Channels, MP-C-36A.....8, DO1–DO8

Contact rating.....250 VAC/30 VDC, 2 A, Pilot Duty (C300)

Switch type.....Form A Relay
.....Single Pole Single Throw
.....Normally Open

Isolation contact to system ground.....3000 VAC

Cycle life (Resistive load).....At least 100,000 cycles

Minimum pulse width.....100 ms

High power relay outputs, DO

Channels, MP-C-15A.....1, DO7

Channels, MP-C-18A.....1, DO8

Channels, MP-C-18B.....0

Channels, MP-C-24A.....0

Channels, MP-C-36A.....0

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MP-C

SmartX IP Controller

Contact rating.....250 VAC/24 VDC, 12 A, Pilot Duty (B300)
Switch type.....Form A Relay
.....Single Pole Single Throw
.....Normally Open
Isolation contact to system ground.....5000 VAC
Cycle life (Resistive load) .....At least 100,000 cycles
Minimum pulse width .....100 ms

Triac outputs, DO

Channels, MP-C-15A 6, DO1–DO6
Channels, MP-C-18A 4, DO1–DO4
Channels, MP-C-18B 8, DO1–DO8
Channels, MP-C-24A 0
Channels, MP-C-36A 0
Output rating (for each triac output) .....Max. 0.5 A
Voltage.....24 VAC +/-20 %
Commons .....COM1 for DO1 and DO2 (on MP-C-15A, -18A, -18B)
.....COM2 for DO3 and DO4 (on MP-C-15A, -18A, -18B)
.....COM3 for DO5 and DO6 (on MP-C-15A, -18B)
.....COM4 for DO7 and DO8 (on MP-C-18B only)
The common terminals can be connected to 24 VAC or to ground.
Common voltage, high side output.....24 VAC
Common voltage, low side output .....0 VAC (ground)
Minimum pulse width .....100 ms
Triac output protection.....MOV and snubber across each triac output
.....MOV from triac COM to ground

Terminals

Be sure to follow proper installation wiring diagrams and instructions, including these instructions:

- All MP-C models have several RET terminals for connection of I/O returns, so a common chassis/signal ground rail is optional and may not be needed.
- Individual 24 VDC power sources to the field must be current limited to maximum 4 A for UL compliant installations, and maximum 6 A in other areas.
- For more information on wiring, see Hardware Reference Guide.

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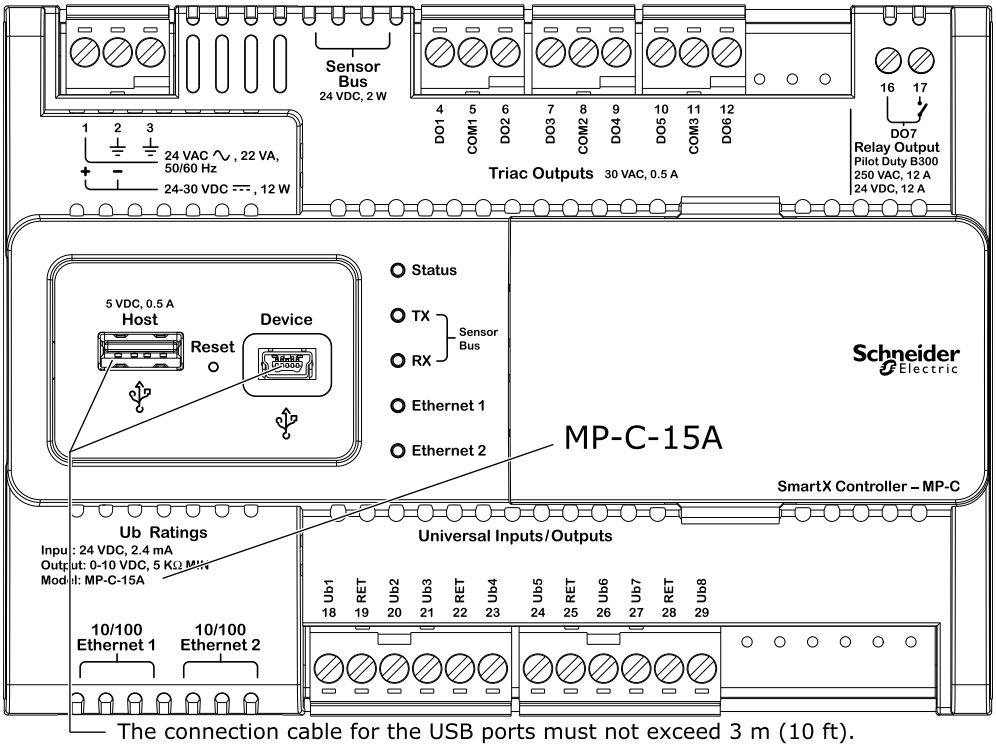
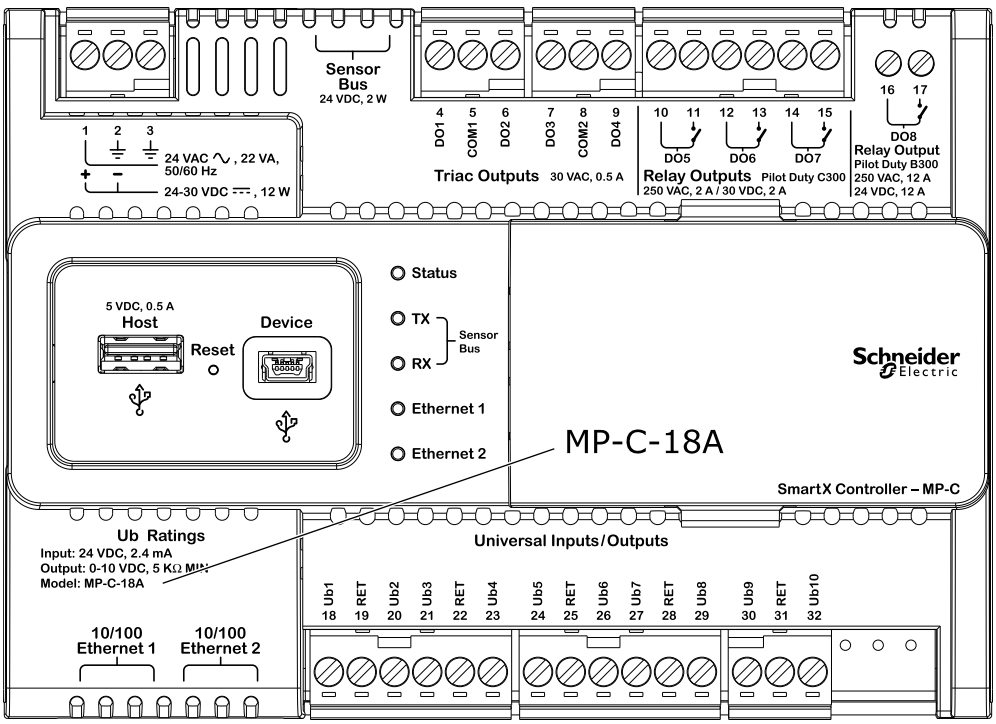
MP-C

SmartX IP Controller



MP-C-15A



MP-C-18A

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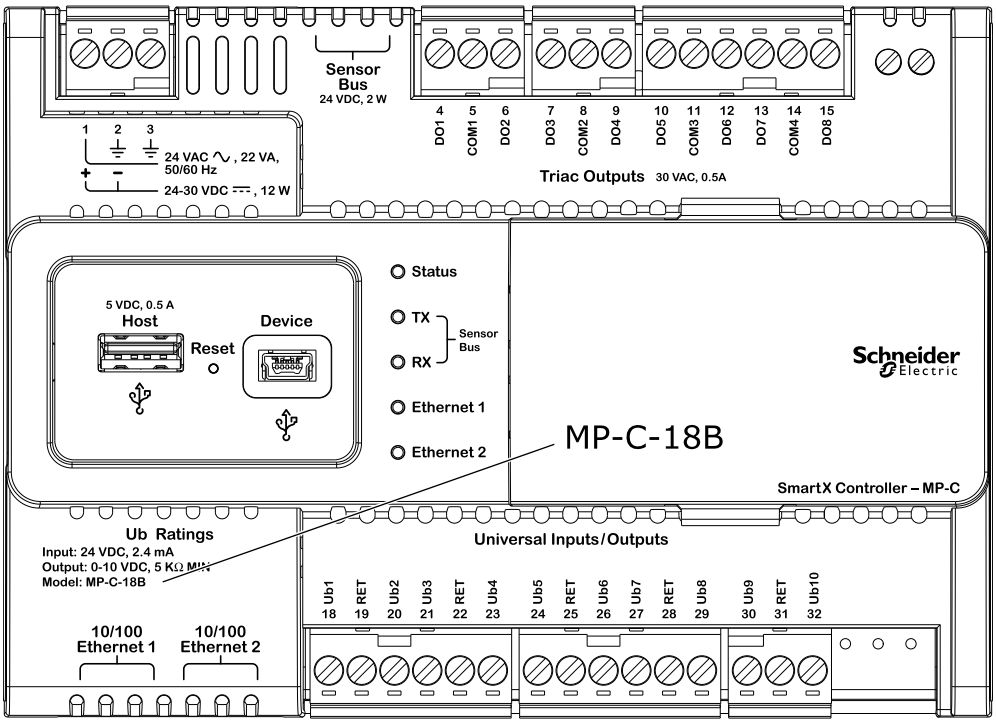
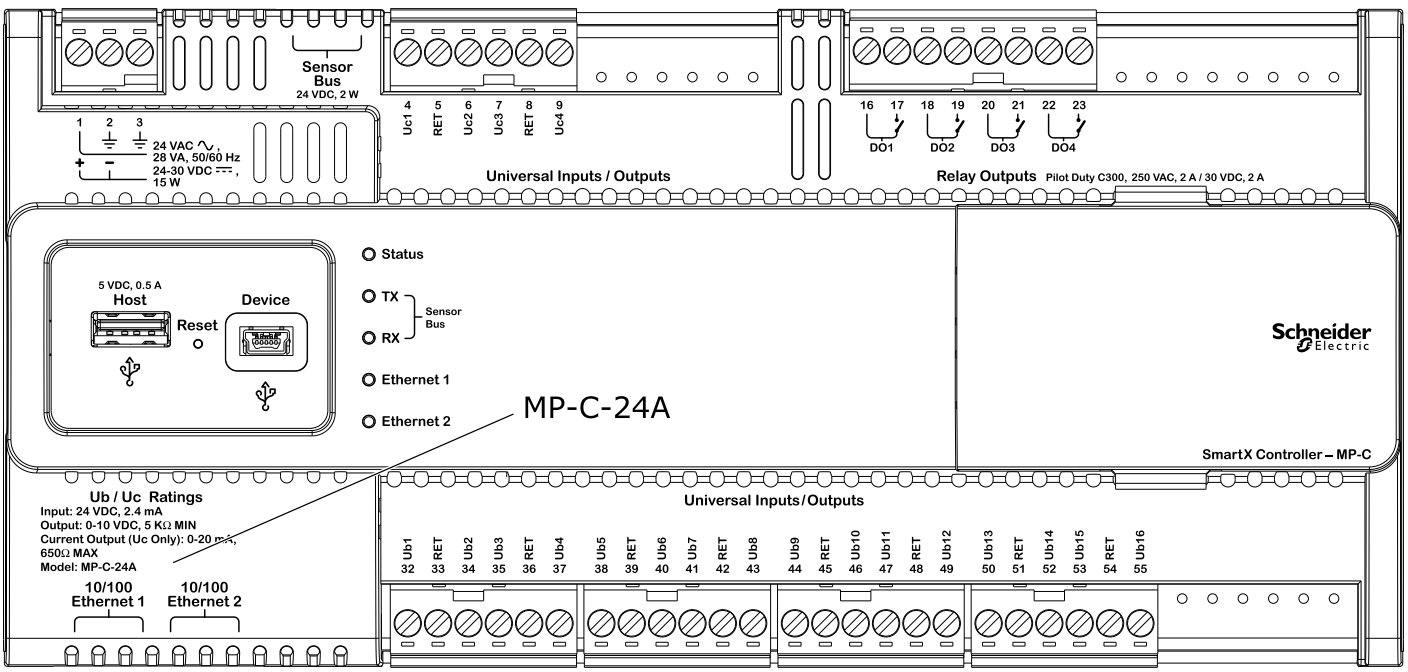
MP-C

SmartX IP Controller



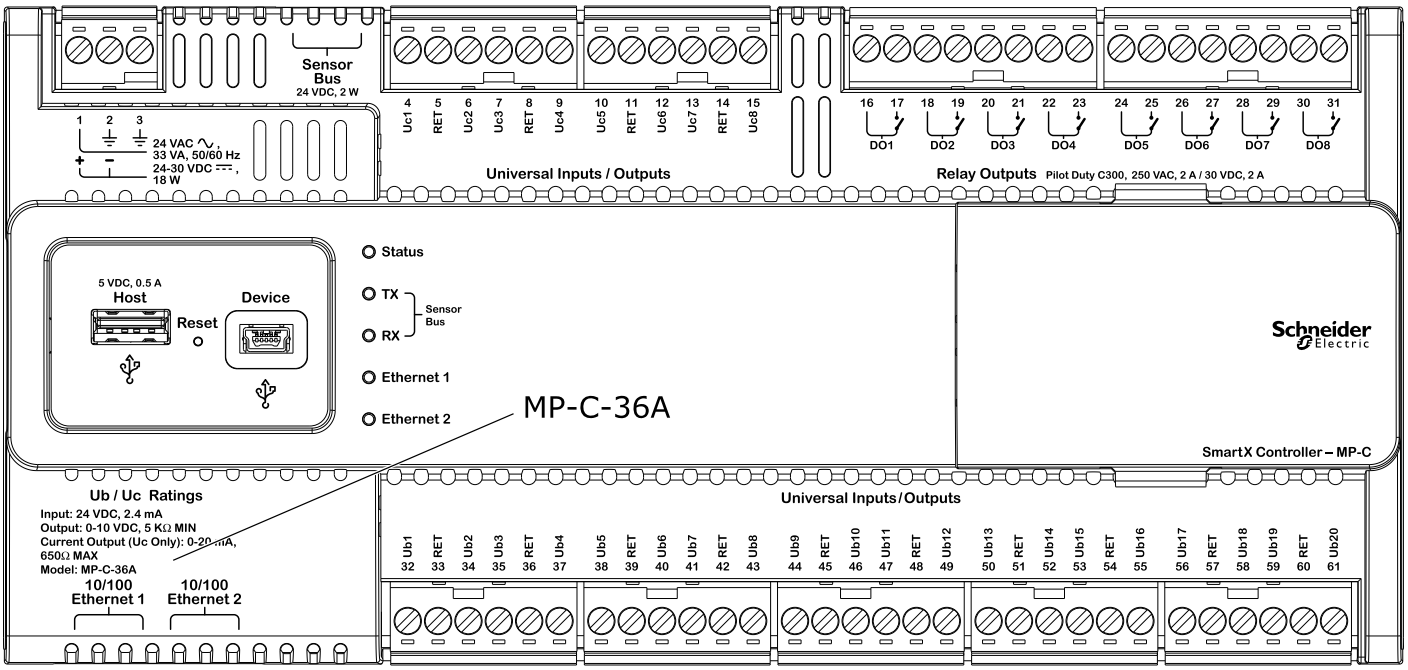
MP-C-18B



MP-C-24A

MP-C

SmartX IP Controller



MP-C-36A

Part Numbers in AMER Region for Network Connectivity Accessories

Product description[a]	Part number (AMER region)
Cat 6 field-term plug, UTP	ACTPG6TLU001
Cat 6 pull-through plug, UTP, 100-pack	ACTPG6PTU100
Actassi crimping tool	ACTTLCPT
Cat 6 cable, UTP, 1000 ft (305 m), CMP, green	ACT4P6UCP1ARXGR
Cat 6 patch cord, UTP, 30 ft (9 m), CMP, green	ACTPC6UBCP30AGR
Cat 6 patch cord, UTP, 50 ft (15 m), CMP, green	ACTPC6UBCP50AGR
Cat 6 patch cord, UTP, 70 ft (21 m), CMP, green	ACTPC6UBCP70AGR
Cat 6 patch cord, UTP, 90 ft (27 m), CMP, green	ACTPC6UBCP90AGR
Cat 5e pull-through plug, UTP, 100-pack	ACTPG5PTU100
Cat 5e cable, UTP, 1000 ft (305 m), CMP, green	ACT4P5UCP1ARXGR
Cat 5e patch cord, UTP, 30 ft (9 m), CMP, green	ACTPC5EUBCP30AGR
Cat 5e patch cord, UTP, 50 ft (15 m), CMP, green	ACTPC5EUBCP50AGR
Cat 5e patch cord, UTP, 70 ft (21 m), CMP, green	ACTPC5EUBCP70AGR
Cat 5e patch cord, UTP, 90 ft (27 m), CMP, green	ACTPC5EUBCP90AGR

a) Abbreviations: UTP (Unshielded Twisted Pair), CMP (Plenum-rated cable)

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MP-C
SmartX IP Controller

Part Numbers in EMEA Region for Network Connectivity Accessories

Product description[a]	Part number (EMEA region)
Cat 6 field-term plug, UTP	ACTPG6TLU001
Cat 6 pull-through plug, UTP, 100-pack	ACTPG6PTU100
Actassi crimping tool	ACTTLCPT
Cat 6 LAN cable, UTP, 4-Pair, 250 MHz, LSZH, 305 m (1000 ft)	VDICD116118
Cat 6 patch cord, UTP, 10 m (32 ft), LSZH, green	ACTPC6UBLS100GR
Cat 6 patch cord, UTP, 15 m (49 ft), LSZH, green	ACTPC6UBLS150GR
Cat 6 patch cord, UTP, 20 m (65 ft), LSZH, green	ACTPC6UBLS200GR
Cat 6 patch cord, UTP, 25 m (82 ft), LSZH, green	ACTPC6UBLS250GR
Cat 5e pull-through plug, UTP, 100-pack	ACTPG5PTU100
Cat 5e cable, UTP, 1000 ft (305 m), CMP, green	VDICD115118
Cat 5e patch cord, UTP, 10 m (32 ft), LSZH, green	ACTPC5EUBLS100GR
Cat 5e patch cord, UTP, 15 m (49 ft), LSZH, green	ACTPC5EUBLS150GR
Cat 5e patch cord, UTP, 20 m (65 ft), LSZH, green	ACTPC5EUBLS200GR
Cat 5e patch cord, UTP, 25 m (82 ft), LSZH, green	ACTPC5EUBLS250GR

a) Abbreviations: UTP (Unshielded Twisted Pair), CMP (Plenum-rated cable), LSZH (Low Smoke Zero Halogen)

Part Numbers in APAC Region for Network Connectivity Accessories

Product description[a]	Part number (APAC region)
Cat 6 field-term plug, UTP	ACTPG6TLU001
Cat 6 pull-through plug, UTP, 100-pack	ACTPG6PTU100
Actassi crimping tool	ACTTLCPT
Cat 6 LAN cable, 305 m	2D4P6IPV3B-GR
Cat 6 patch lead, UTP, 10 m (32 ft), green	RJ6_100PL-GR
Cat 6 patch lead, UTP, 15 m (49 ft), green	RJ6_150PL-GR
Cat 6 patch lead, UTP, 20 m (65 ft), green	RJ6_200PL-GR
Cat 6 patch lead, UTP, 25 m (82 ft), green	RJ6_250PL-GR
Cat 5e field-term plug, UTP	ACTPG5ETLU001
Cat 5e pull-through plug, UTP, 100-pack	ACTPG5EPTU100
Cat 5e LAN cable, 305 m (1000 ft)	2D4P5IPV3B-GR
Cat 5e patch lead, UTP, 10 m (32 ft), green	RJ5_100PL-GR
Cat 5e patch lead, UTP, 15 m (49 ft), green	RJ5_150PL-GR
Cat 5e patch lead, UTP, 20 m (65 ft), green	RJ5_200PL-GR
Cat 5e patch lead, UTP, 25 m (82 ft), green	RJ5_250PL-GR

a) Abbreviations: UTP (Unshielded Twisted Pair)

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MP-C

SmartX IP Controller

Regulatory Notices

Federal Communications Commission
FCC Rules and Regulations CFR 47, Part 15, Class B
This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference. (2) This device must accept any interference received, including interference that may cause undesired operation.

Industry Canada
This Class B digital apparatus complies with Canadian ICES-003.
Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

Regulatory Compliance Mark (RCM) - Australian Communications and Media Authority (ACMA)
This equipment complies with the requirements of the relevant ACMA standards made under the Radiocommunications Act 1992 and the Telecommunications Act 1997. These standards are referenced in notices made under section 182 of the Radiocommunications Act and 407 of the Telecommunications Act.

CE - Compliance to European Union (EU)
2014/30/EU Electromagnetic Compatibility Directive
2014/35/EU Low Voltage Directive
2011/65/EU Restriction of Hazardous Substances (RoHS) Directive
This equipment complies with the rules, of the Official Journal of the European Union, for governing the Self Declaration of the CE Marking for the European Union as specified in the above directive(s) per the provisions of the following standards: EN 60730-1, EN 60730-2-11, and EN 50491-3 Safety Standards.

WEEE - Directive of the European Union (EU)
This equipment and its packaging carry the waste of electrical and electronic equipment (WEEE) label, in compliance with European Union (EU) Directive 2012/19/EU, governing the disposal and recycling of electrical and electronic equipment in the European community.

UL 916 Listed products for the United States and Canada, Open Class Energy Management Equipment. UL file E80146.

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MP-V

SmartX IP Controller

Introduction

SmartX IP Controller – MP-V is a multi-purpose, fully programmable, IP based field controller dedicated for VAV cooling and heating applications. MP-V integrates a controller, a damper actuator, and an air flow sensor in a single compact package for ease of installation. MP-V can either be used as a standalone BACnet/IP field controller or as part of an EcoStruxure BMS with a SmartX AS-P or AS-B server or an Enterprise Server as the parent server. MP-V comes in two models with different I/O count.

The MP-V has the following features:

- IP enabled with dual port Ethernet switch
- Integrated damper actuator with feedback signal
- Factory-calibrated air flow sensor
- High reliability
- Sensor bus for living space sensors
- Mobile commissioning application
- Full EcoStruxure Building Operation software support, providing efficient engineering tools

IP connectivity and flexible network topologies

The MP Series controllers are based on open protocols that simplify interoperability, IP configuration, and device management:

- IP addressing
- BACnet/IP communications
- DHCP for easy network configuration

The MP Series controllers have a dual-port Ethernet switch, which enables flexible network topologies:

- Star
- Daisy chain
- Rapid Spanning Tree Protocol (RSTP) ring

In a star topology, the controller and the parent EcoStruxure BMS server are individually connected to an Ethernet switch. You can reduce the installation time and cost by daisy-chaining multiple controllers together. You can use an RSTP ring topology when you want failures of a single controller to be detected and recovered quickly and efficiently.

Models with a versatile mix of I/O points

MP-V comes in two models with different I/O point count and a versatile mix of I/O point types that match a wide variety of VAV applications.

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MP-V

SmartX IP Controller

I/O Point Types by MP-V Models

I/O Point Types	MP-V-7A	MP-V-9A
Universal inputs	3	4
Triac outputs	3	3
Analog outputs	1	2

Configurations by I/O Point Types

Configurations	Universal Inputs	Triac Outputs	Analog Outputs
Digital inputs	yes	-	-
Counter inputs	yes	-	-
Supervised inputs	yes	-	-
Voltage inputs (0 to 10 VDC)	yes	-	-
Current inputs (0 to 20 mA)	yes	-	-
Temperature inputs	yes	-	-
Resistive inputs	yes	-	-
2-wire RTD temperature inputs	yes	-	-
Digital outputs	-	yes	-
Digital pulsed outputs	-	yes	-
PWM outputs	-	yes	-
Tristate outputs	-	yes	-
Tristate pulsed outputs	-	yes	-
Voltage outputs (0 to 10 VDC)	-	-	yes
Current outputs (0 to 20 mA)	-	-	yes

Universal inputs

The universal inputs are ideal for any mix of temperature, pressure, flow, status points, and similar point types in a building control system.

As counter inputs, they are commonly used in energy metering applications. As RTD inputs, they are ideal for temperature points in a building control system. As supervised inputs, they are used for security applications where it is critical to know whether or not a wire has been cut or shorted. These events provide a separate indication of alarms and trouble conditions to the system.

For all analog inputs, maximum and minimum levels can be defined to automatically detect over-range and under-range values.

Triac outputs

The triac outputs can be used in many applications to switch 24 VAC on or off for external loads such as actuators, relays, or indicators. The triac outputs are isolated from the controller. Triacs are silent and do not suffer from relay contact wear.

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MP-V

SmartX IP Controller

Analog outputs

The analog outputs are capable of supporting analog voltage or current point types, without the need for external bias resistors. Therefore, analog outputs support a wide range of devices, such as actuators.

Integrated damper actuator with feedback signal

The integrated damper actuator allows for simplified installation of MP-V directly over the damper shaft. This eliminates the need for separate installation, wiring, and positioning of the damper motor. MP-V uses the same actuator mechanics as many Schneider Electric VAV controller models from the Andover Continuum, TAC Vista, TAC I/A Series, and TAC I/NET product lines. The feedback signal from the actuator makes it possible to determine the exact position of the damper. The actuator also features a push button for manual positioning of the damper during commissioning.

Factory-calibrated air flow sensor

The factory-calibrated air flow sensor uses a state-of-the-art technology that requires no air flow from the velocity probe. Unlike flow-through sensors, the sensor does not impose rigid requirements on tubing, dust, or filters, and the sensor is not affected by errors induced on the local probe pressure readings. The sensor requires no maintenance and a minimum of field adjustments.

High reliability

The MP Series controllers support local trends, schedules, and alarms, enabling local operation when the controller is offline or used in standalone applications.

The battery-free power backup of the memory and real-time clock prevents data loss and ensures seamless and quick recovery after a power failure.

WorkStation allows you to update the firmware of multiple MP Series controllers at the same time and with minimum down time. The EcoStruxure BMS server keeps track of the installed firmware to support backup, restore, and replacement of the controllers and sensors. The server can host controllers of different firmware versions.

Sensor bus for living space sensors

The MP Series controllers provide an interface designed for the SmartX Sensor family of living space sensors. The SmartX Sensors offer an efficient way to sense the temperature, humidity, CO_2, and occupancy in a room. The SmartX Sensors are available with different combinations of sensor types and various covers and user interface options, such as touchscreen, setpoint and override buttons, and blank covers.

SmartX Sensors

The sensor bus provides both power and communications for up to four sensors that are daisy-chained using standard Cat 5 (or higher) cables. The maximum number of sensors that can be connected to a controller varies depending on the sensor model and the combination of cover and sensor base type:

- Blank covers: Up to four sensors of any combination of sensor base types
- 3-button and touchscreen covers:
  - Up to two sensor bases with CO_2 option
  - Up to four sensor bases without CO_2 option
- SmartX LCD temperature sensors: Up to four sensors are supported

The maximum total length of the sensor bus is 61 m (200 ft). For more information, see the SmartX Living Space Sensors Specification Sheet.

Mobile commissioning application

The eCommission SmartX Controllers mobile application is designed for local configuration, field deployment, and commissioning of MP Series controllers, and air flow balancing of VAV units. The mobile application reduces the commissioning time, allows flexibility in project execution, and eliminates dependencies on network infrastructure.

The mobile application is designed for use with Android, Apple (iOS), and Microsoft Windows 10 devices. For more information, see the eCommission SmartX Controllers Specification Sheet.

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eCommission SmartX Controllers mobile app

Using the eCommission SmartX Controllers mobile application, you can connect to one or many MP Series controllers. You can connect to a single MP Series controller using the eCommission Bluetooth Adapter connected to a SmartX Sensor. You can connect to a network of MP Series controllers on the local IP network, using a wireless access point or a network switch.

Device configuration

With the eCommission SmartX Controllers mobile application, you can easily discover MP Series controllers on the IP network and change each controller's configuration, including the BACnet and IP network settings, location, and parent server. To save engineering time, you can save common device settings and then reuse them for controllers of the same model.

Field deployment and I/O checkout

The eCommission SmartX Controllers mobile application does not require an EcoStruxure BMS server or a network infrastructure to be in place. You can use the mobile application to load the controller application directly into the local MP Series controller and deploy the controller. The controller application can be created offline using Project Configuration Tool or WorkStation. You can also perform an I/O checkout to ensure that the controller's I/O points are configured, wired, and operating correctly.

Air flow balancing

Using the eCommission SmartX Controllers mobile application, you can perform air flow balancing of VAV units controlled by MP-Vs. An intuitive workflow automatically guides you through the process. After the flow balancing, you can generate a report in HTML format for one or more VAV units. The balancing parameters associated with each MP-V are stored in the parent server, which makes it easier to replace the controller if necessary.

Full EcoStruxure Building Operation software support

The power of the MP Series controller is fully realized when it is part of an EcoStruxure BMS, which provides the following benefits:

- WorkStation/WebStation interface
- Script and Function Block programming options
- Device discovery
- Engineering efficiency

WorkStation/WebStation interface

WorkStation and WebStation provide a consistent user experience regardless of which EcoStruxure BMS server the user is logged on to. The user can log on to the parent EcoStruxure BMS server to engineer, commission, supervise, and monitor the MP Series controller and its I/O as well as its attached SmartX Sensors. For more information, see the WorkStation and WebStation specification sheets.

Script and Function Block programming options

Unique to the industry, the MP Series controllers have both Script and Function Block programming options. This flexibility assures that the best programming method can be selected for the application. Existing programs can easily be reused between the EcoStruxure BMS server and the controller.

Device discovery

The enhanced Device Discovery in WorkStation enables you to easily identify MP Series controllers on a BACnet network and to associate the controllers with their parent server.

Engineering efficiency

The engineering and maintenance of MP Series controllers can be done very efficiently using the EcoStruxure Building Operation reusability features. With these features, you can create library items (Custom Types) for a complete controller application that contains programs and all necessary objects such as trends, alarms, and schedules. The controller application in the Custom Types library is reusable across all controllers of the same model. You can use the controller application as a base for creating new

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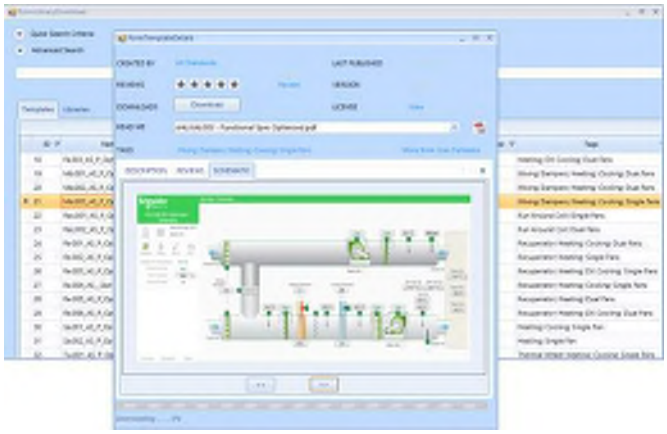
controllers intended for similar applications. You can then edit the controller application, and the changes are automatically replicated to all controllers, while each controller keeps its local values.

WorkStation supports both online and offline engineering of MP Series controllers. You can make the configuration changes online or use database mode to make the changes offline. In database mode, the changes are saved to the EcoStruxure Building Operation database so that you can apply the changes to the controllers later.

Project Configuration Tool enables you to perform all the engineering off site, without the need for physical hardware, which minimizes the time you need to spend on site. You can run the EcoStruxure BMS servers virtually and engineer the MP Series controllers, before you deploy your server and controller applications to the servers and controllers on site. For more information, see the Project Configuration Tool specification sheet.

In addition, you can use Automated Engineering Tool to facilitate your engineering process when using MP Series controllers. This tool provides access to a library of standard controller applications. These standard applications can be quickly configured and customized using the wizards and mass edit functions provided in the tool and then loaded into your target server. The tool also enables the quick creation of your own templates based on MP Series controller applications that you have developed. This facilitates a standard approach and drives the ability to easily reuse and duplicate common controller applications. For more information, see the Automated Engineering Tool specification sheet.



Library of standard HVAC applications

Part Numbers

Product	Part number
MP-V-7A	SXWMPV7AX10001
MP-V-9A	SXWMPV9AX10001
Spare terminal blocks for all MP-V models (1 x 2-pin, 2 x 3-pin, 2 x 4-pin, 1 x 5-pin, 1 x 6-pin terminal blocks)	SXWMPVCON10001
Adapter for damper shaft diameter 9.5 mm (0.375 inch)	AM-135
eCommission Bluetooth Adapter	SXWBTAECXX10001

Specifications

AC input

Nominal voltage .....24 VAC
Operating voltage range .....+/-20 %
Frequency .....50/60 Hz
Maximum power consumption (MP-V-7A) .....21 VA
Maximum power consumption (MP-V-9A) .....22 VA
Power input protection .....MOV suppression and internal fuse

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Environment

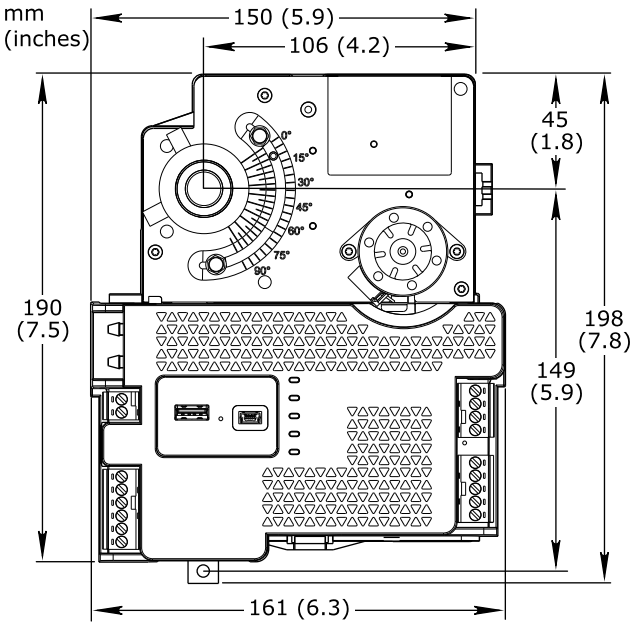
Ambient temperature, operating .....0 to 50 °C (32 to 122 °F)
Ambient temperature, storage .....-40 to +70 °C (-40 to +158 °F)
Maximum humidity.....95 % RH non-condensing

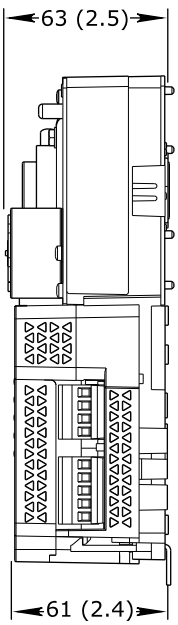
Material

Plastic flame rating UL94 V-0
Ingress protection rating .....IP 20

Mechanical

Dimensions .....161 W x 198 H x 63 D mm (6.3 W x 7.8 H x 2.5 D in.)





Weight .....1.13 kg (2.5 lb)
Installation .....Over the damper shaft
Terminal blocks .....Removable

Software compliance

EcoStruxure Building Operation software .....version 2.0 or later

Agency compliances

Emission .....RCM; EN 61000-6-3; EN 50491-5-2; FCC Part 15, Sub-part B, Class B
Immunity .....EN 61000-6-2; EN 50491-5-3
Safety .....EN 60730-1; EN 60730-2-11; EN 50491-3; UL 916 C-UL US Listed
Fire performance in air-handling spaces[a] ..... UL 2043
a) MP-V-7A and MP-V-9A are approved for plenum applications.

Real-time clock

Accuracy, at 25 °C (77 °F) .....+/-1 minute per month
Backup time, at 25 °C (77 °F) .....7 days minimum

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Communication ports

Ethernet ..... Dual 10/100BASE-TX (RJ45)
USB ..... USB 2.0, 5 VDC, 2.5 W, 1 device port (mini-B) and 1 host port (type-A)
Sensor Bus .....24 VDC, 2 W, RS-485 (RJ45)
Sensor Bus protection .....Transient voltage suppressors on communication and power signals

Communications

BACnet .....BACnet/IP, port configurable, default 47808
.....BTL B-AAC (BACnet Advanced Application Controller)[a]
a) See the BTL Product Catalog for up-to-date details on BTL listed firmware revisions on BACnet International's home page.

CPU

Frequency ..... 500 MHz
Type .....ARM Cortex-A7 dual-core
DDR3 SDRAM .....128 MB
NOR flash memory .....32 MB
Memory backup .....128 kB, FRAM, non-volatile

Damper actuator

Torque rating .....6 Nm (53 lbf.in)
Stroke .....0° to 90°, fully adjustable
Timing .....Approximately 2 seconds/degree at 60 Hz and 2.4 seconds/degree at 50 Hz for 90° rotation at 24 VAC
Position indication .....Visual indication
Damper position feedback .....Yes
Manual override ..... Push-button clutch release
Damper shaft diameter .....12.7 mm (0.5 inch) or 9.5 mm (0.375 inch)
.....Adapter kit AM-135 is required for 9.5 mm (0.375 inch) diameter shafts.
Damper shaft minimum length (from VAV box) .....22.2 mm (0.875 inch)

Air flow sensor

Range .....0 to 249 Pa (0 to 1 inH_2O)
Resolution .....0.33 Pa (0.001 inH_2O) at 25°C (77°F)
Accuracy .....±5% of 249 Pa (1.00 inH_2O) span at 25°C (77°F)

Universal inputs, UI

Channels, MP-V-7A 3, UI1–UI3
Channels, MP-V-9A 4, UI1–UI4
Absolute maximum ratings .....-0.5 to +24 VDC
A/D converter resolution .....16 bits
Universal input protection .....Transient voltage suppressor on each input

Digital inputs

Range.....Dry contact switch closure or open collector/open drain, 24 VDC, typical wetting current 2.4 mA
Minimum pulse width .....150 ms

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Counter inputs

Range.....Dry contact switch closure or open collector/open drain, 24 VDC, typical wetting current 2.4 mA
Minimum pulse width.....20 ms
Maximum frequency.....25 Hz

Supervised inputs

5 V circuit, 1 or 2 resistors
Monitored switch combinations.....Series only, parallel only, and series and parallel
Resistor range.....1 to 10 kohm
For a 2-resistor configuration, each resistor must have the same value +/- 5 %

Voltage inputs

Range.....0 to 10 VDC
Accuracy.....+/-(7 mV + 0.2 % of reading)
Resolution.....1.0 mV
Impedance.....100 kohm

Current inputs

Range.....0 to 20 mA
Accuracy.....+/-(0.01 mA + 0.4 % of reading)
Resolution.....1 µA
Impedance.....47 ohm

Resistive inputs

10 ohm to 10 kohm accuracy.....$+/-(7 + 4 \times 10^{-3} \times R)$ ohm
R = Resistance in ohm

10 kohm to 60 kohm accuracy.....$+/-(4 \times 10^{-3} \times R + 7 \times 10^{-8} \times R^2)$ ohm
R = Resistance in ohm

Temperature inputs (thermistors)

Range.....-50 to +150 °C (-58 to +302 °F)

Supported thermistors

Honeywell.....20 kohm
Type I (Continuum).....10 kohm
Type II (I/NET).....10 kohm
Type III (Satchwell).....10 kohm
Type IV (FD).....10 kohm
Type V (FD w/ 11k shunt).....Linearized 10 kohm
Satchwell D?T.....Linearized 10 kohm
Johnson Controls.....2.2 kohm
Xenta.....1.8 kohm
Balco.....1 kohm

Measurement accuracy

20 kohm.....-50 to -30 °C: +/-1.5 °C (-58 to -22 °F: +/-2.7 °F)

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-30 to 0 °C: +/-0.5 °C (-22 to +32 °F: +/-0.9 °F)
0 to 100 °C: +/-0.2 °C (32 to 212 °F: +/-0.4 °F)
100 to 150 °C: +/-0.5 °C (212 to 302 °F: +/-0.9 °F)

10 kohm, 2.2 kohm, and 1.8 kohm -50 to -30 °C: +/-0.75 °C (-58 to -22 °F: +/-1.35 °F)
-30 to +100 °C: +/-0.2 °C (-22 to +212 °F: +/-0.4 °F)
100 to 150 °C: +/-0.5 °C (212 to 302 °F: +/-0.9 °F)

Linearized 10 kohm -50 to -30 °C: +/-2.0 °C (-58 to -22 °F: +/-3.6 °F)
-30 to 0 °C: +/-0.75 °C (-22 to +32 °F: +/-1.35 °F)
0 to 100 °C: +/-0.2 °C (32 to 212 °F: +/-0.4 °F)
100 to 150 °C: +/-0.5 °C (212 to 302 °F: +/-0.9 °F)

1 kohm -50 to +150 °C: +/-1.0 °C (-58 to +302° F: +/-1.8 °F)

RTD temperature inputs

Supported RTDs Pt1000

Pt1000

Range -50 to +150 °C (-58 to +302 °F)

Measurement accuracy -50 to +70 °C: +/-0.5 °C (-58 to +158 °F: +/-0.9 °F)
70 to 150 °C: +/-0.7 °C (158 to 302 °F: +/-1.3 °F)

RTD temperature wiring

Maximum wire resistance 20 ohm/wire (40 ohm total)

Maximum wire capacitance 60 nF
The wire resistance and capacitance typically corresponds to a 200 m wire.

Triac outputs, DO

Channels, MP-V-7A 3, DO1–DO3

Channels, MP-V-9A 3, DO1–DO3

Output rating (for each triac output) Max. 0.5 A

Voltage 24 VAC +/-20 %

Commons COM (terminal number 18)
The common terminal COM can be connected to 24 VAC or to ground.

Common voltage, high side output 24 VAC

Common voltage, low side output 0 VAC (ground)

Minimum pulse width 100 ms

Triac output protection MOV and snubber across each triac output
MOV from triac COM to ground

Analog outputs, AO

Channels, MP-V-7A 1, VO1/CO1

Channels, MP-V-9A 2, VO1/CO1 and VO2/CO2

Analog output protection Transient voltage suppressor on each output

Voltage outputs

Range 0 to 10 VDC

Accuracy +/-60 mV

Resolution 10 mV

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MP-V

SmartX IP Controller

Minimum load resistance.....5 kohm to ground
Load range.....0 to +2 mA
Terminals .....Voltage Output (VO), Return (RET)

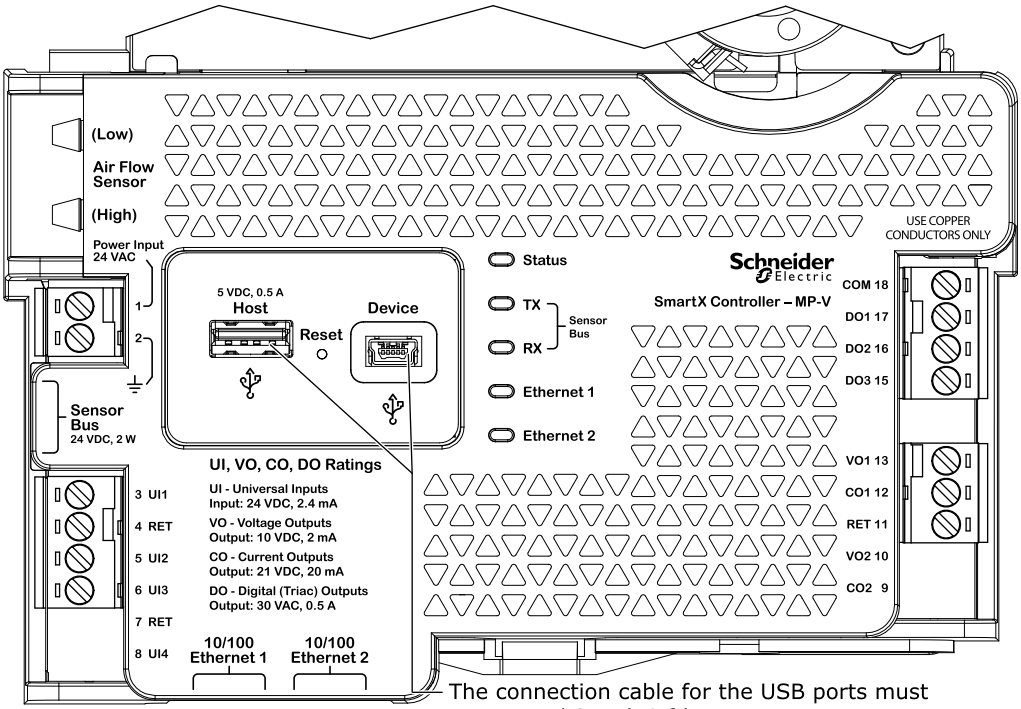
Current outputs

Range .....0 to 20 mA
Accuracy .....+/-0.2 mA
Resolution.....21 µA
Load range.....0 to 650 ohm
Terminals .....Current Output (CO), Return (RET)

Terminals

Be sure to follow proper installation wiring diagrams and instructions, including these instructions:

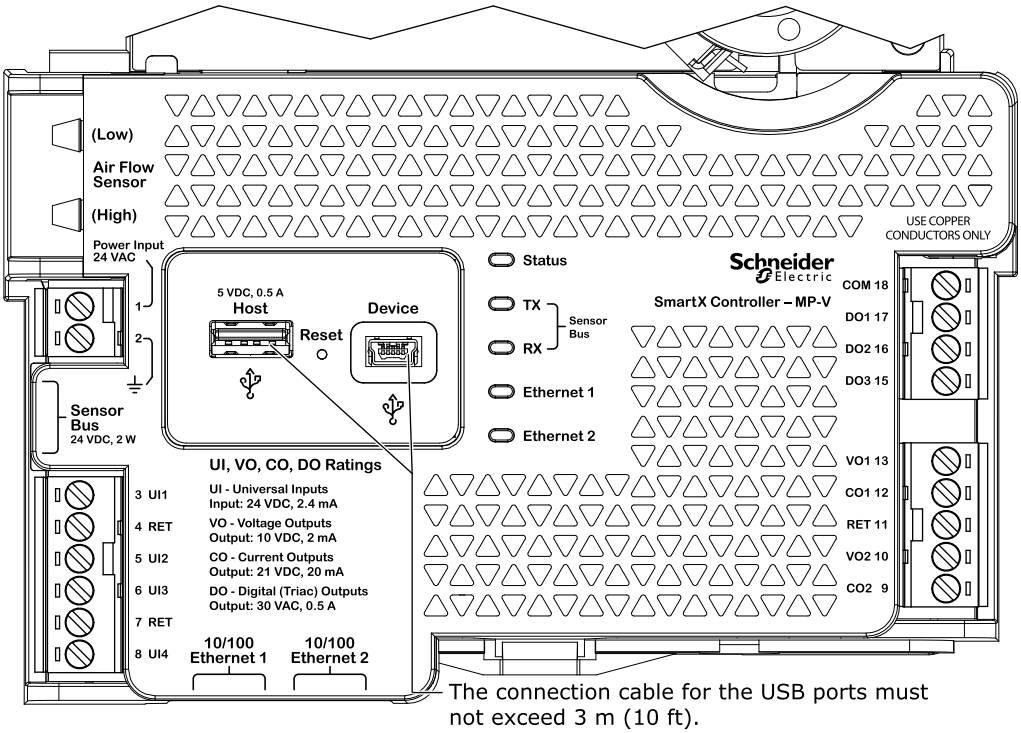
- MP-V-7A and MP-V-9A have several RET terminals for connection of I/O returns, so a common chassis/signal ground rail is optional and may not be needed.
- Individual 24 VDC power sources to the field must be current limited to maximum 4 A for UL compliant installations, and maximum 6 A in other areas.
- For more information on wiring, see Hardware Reference Guide.



MP-V-7A

MP-V

SmartX IP Controller



MP-V-9A

Part Numbers in AMER Region for Network Connectivity Accessories

Product description[a]	Part number (AMER region)
Cat 6 field-term plug, UTP	ACTPG6TLU001
Cat 6 pull-through plug, UTP, 100-pack	ACTPG6PTU100
Actassi crimping tool	ACTTLCPT
Cat 6 cable, UTP, 1000 ft (305 m), CMP, green	ACT4P6UCP1ARXGR
Cat 6 patch cord, UTP, 30 ft (9 m), CMP, green	ACTPC6UBCP30AGR
Cat 6 patch cord, UTP, 50 ft (15 m), CMP, green	ACTPC6UBCP50AGR
Cat 6 patch cord, UTP, 70 ft (21 m), CMP, green	ACTPC6UBCP70AGR
Cat 6 patch cord, UTP, 90 ft (27 m), CMP, green	ACTPC6UBCP90AGR
Cat 5e pull-through plug, UTP, 100-pack	ACTPG5PTU100
Cat 5e cable, UTP, 1000 ft (305 m), CMP, green	ACT4P5UCP1ARXGR
Cat 5e patch cord, UTP, 30 ft (9 m), CMP, green	ACTPC5EUBCP30AGR
Cat 5e patch cord, UTP, 50 ft (15 m), CMP, green	ACTPC5EUBCP50AGR
Cat 5e patch cord, UTP, 70 ft (21 m), CMP, green	ACTPC5EUBCP70AGR
Cat 5e patch cord, UTP, 90 ft (27 m), CMP, green	ACTPC5EUBCP90AGR

a) Abbreviations: UTP (Unshielded Twisted Pair), CMP (Plenum-rated cable)

MP-V

SmartX IP Controller

Part Numbers in EMEA Region for Network Connectivity Accessories

Product description[a]	Part number (EMEA region)
Cat 6 field-term plug, UTP	ACTPG6TLU001
Cat 6 pull-through plug, UTP, 100-pack	ACTPG6PTU100
Actassi crimping tool	ACTTLCPT
Cat 6 LAN cable, UTP, 4-Pair, 250 MHz, LSZH, 305 m (1000 ft)	VDICD116118
Cat 6 patch cord, UTP, 10 m (32 ft), LSZH, green	ACTPC6UBLS100GR
Cat 6 patch cord, UTP, 15 m (49 ft), LSZH, green	ACTPC6UBLS150GR
Cat 6 patch cord, UTP, 20 m (65 ft), LSZH, green	ACTPC6UBLS200GR
Cat 6 patch cord, UTP, 25 m (82 ft), LSZH, green	ACTPC6UBLS250GR
Cat 5e pull-through plug, UTP, 100-pack	ACTPG5PTU100
Cat 5e cable, UTP, 1000 ft (305 m), CMP, green	VDICD115118
Cat 5e patch cord, UTP, 10 m (32 ft), LSZH, green	ACTPC5EUBLS100GR
Cat 5e patch cord, UTP, 15 m (49 ft), LSZH, green	ACTPC5EUBLS150GR
Cat 5e patch cord, UTP, 20 m (65 ft), LSZH, green	ACTPC5EUBLS200GR
Cat 5e patch cord, UTP, 25 m (82 ft), LSZH, green	ACTPC5EUBLS250GR

a) Abbreviations: UTP (Unshielded Twisted Pair), CMP (Plenum-rated cable), LSZH (Low Smoke Zero Halogen)

Part Numbers in APAC Region for Network Connectivity Accessories

Product description[a]	Part number (APAC region)
Cat 6 field-term plug, UTP	ACTPG6TLU001
Cat 6 pull-through plug, UTP, 100-pack	ACTPG6PTU100
Actassi crimping tool	ACTTLCPT
Cat 6 LAN cable, 305 m	2D4P6IPV3B-GR
Cat 6 patch lead, UTP, 10 m (32 ft), green	RJ6_100PL-GR
Cat 6 patch lead, UTP, 15 m (49 ft), green	RJ6_150PL-GR
Cat 6 patch lead, UTP, 20 m (65 ft), green	RJ6_200PL-GR
Cat 6 patch lead, UTP, 25 m (82 ft), green	RJ6_250PL-GR
Cat 5e field-term plug, UTP	ACTPG5ETLU001
Cat 5e pull-through plug, UTP, 100-pack	ACTPG5EPTU100
Cat 5e LAN cable, 305 m (1000 ft)	2D4P5IPV3B-GR
Cat 5e patch lead, UTP, 10 m (32 ft), green	RJ5_100PL-GR
Cat 5e patch lead, UTP, 15 m (49 ft), green	RJ5_150PL-GR
Cat 5e patch lead, UTP, 20 m (65 ft), green	RJ5_200PL-GR
Cat 5e patch lead, UTP, 25 m (82 ft), green	RJ5_250PL-GR

a) Abbreviations: UTP (Unshielded Twisted Pair)

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MP-V

SmartX IP Controller

Regulatory Notices

Federal Communications Commission
FCC Rules and Regulations CFR 47, Part 15, Class B
This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference. (2) This device must accept any interference received, including interference that may cause undesired operation.

Industry Canada
This Class B digital apparatus complies with Canadian ICES-003.
Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

Regulatory Compliance Mark (RCM) - Australian Communications and Media Authority (ACMA)
This equipment complies with the requirements of the relevant ACMA standards made under the Radiocommunications Act 1992 and the Telecommunications Act 1997. These standards are referenced in notices made under section 182 of the Radiocommunications Act and 407 of the Telecommunications Act.

CE - Compliance to European Union (EU)
2014/30/EU Electromagnetic Compatibility Directive
2011/65/EU Restriction of Hazardous Substances (RoHS) Directive
This equipment complies with the rules, of the Official Journal of the European Union, for governing the Self Declaration of the CE Marking for the European Union as specified in the above directive(s) per the provisions of the following standards: EN 60730-1, EN 60730-2-11, and EN 50491-3 Safety Standards.

WEEE - Directive of the European Union (EU)
This equipment and its packaging carry the waste of electrical and electronic equipment (WEEE) label, in compliance with European Union (EU) Directive 2012/19/EU, governing the disposal and recycling of electrical and electronic equipment in the European community.

UL 916 Listed products for the United States and Canada, Enclosed Energy Management Equipment. UL file E80146.

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RP-C

SmartX IP Controller

Introduction

SmartX IP Controller – RP-C is a room-purpose, fully programmable, IP based field controller that suits a wide range of HVAC applications. The RP-C can either be used as a standalone BACnet/IP field controller or as part of an EcoStruxure BMS with a SmartX AS-P or AS-B server or an Enterprise Server as the parent server. The RP-C features a wireless chip that allows the mobile commissioning application to connect directly to the controller.

The RP-C has the following features:

- IP enabled with dual-port Ethernet switch
- Full range of controller models
- Versatile onboard I/O point mix
- Optional covers
- Wireless connectivity
- Highly available
- Sensor bus for living space sensors
- Room bus for future support of connected room solutions
- Mobile commissioning application
- Full EcoStruxure Building Operation software support, providing efficient engineering tools

IP connectivity and flexible network topologies

The SmartX IP controllers are based on open protocols that simplify interoperability, IP configuration, and device management:

- IP addressing
- BACnet/IP communications
- DHCP for easy network configuration

The SmartX IP controllers have a dual-port Ethernet switch, which enables flexible network topologies:

- Star
- Daisy chain
- Rapid Spanning Tree Protocol (RSTP) ring

In a star topology, the controller and the parent EcoStruxure BMS server are individually connected to an Ethernet switch. Daisy-chain multiple controllers together to reduce installation time and cost. Use an RSTP ring topology when you want a non-operational controller to be detected and recovered quickly and efficiently.

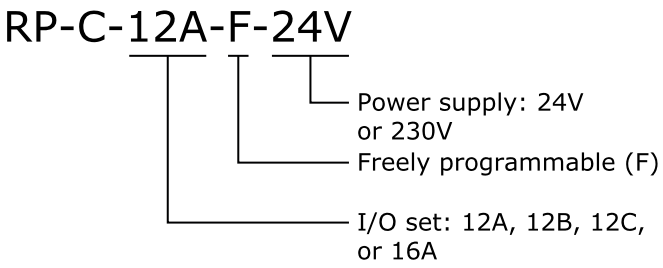
Full range of controller models

The RP-C comes in four different models, which offer four different sets of I/O point types, named 12A, 12B, 12C, and 16A. The RP-C-12A, -12B, and -12C models support 24 VAC/DC power supply, whereas the RP-C-16A model is a 230 VAC model.

03-30017-01-en, April 2019

RP-C

SmartX IP Controller



Freely programmable

The freely programmable RP-C models provide flexibility through support of both Script and Function Block programming options. The RP-C promotes efficiency and standardization through the use of standard controller applications.

Models with a versatile mix of I/O points

The RP-C-12A, -12B, -12C, and -16A models provide 12 or 16 I/O points, consisting of four different sets of I/O point types. The versatile mix of I/O point types match a wide variety of applications. The universal inputs/outputs are highly flexible and can be configured as either inputs or outputs.

I/O Point Types by RP-C Models

I/O Point Types	RP-C-12A model	RP-C-12B model	RP-C-12C model	RP-C-16A model
Universal I/O Type Ub	8	8	4	8
Solid-state relay outputs (MOSFET)	4	-	4	4
Relay outputs Form A	-	3	3	3
High power relay outputs Form C	-	1	1	1

Configurations by I/O Point Types

Configurations	Universal I/O Type Ub	Solid-state Relay Outputs (MOSFET)	Relay Outputs Form A	High Power Relay Outputs Form C
Digital inputs	yes	-	-	-
Counter inputs	yes	-	-	-
Supervised inputs	yes	-	-	-
Voltage inputs (0 to 10 VDC)	yes	-	-	-
Current inputs (0 to 20 mA)	yes	-	-	-
Temperature inputs	yes	-	-	-
Resistive inputs	yes	-	-	-
2-wire RTD temperature inputs	yes	-	-	-

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RP-C

SmartX IP Controller

Continued

Configurations	Universal I/O Type Ub	Solid-state Relay Outputs (MOSFET)	Relay Outputs Form A	High Power Relay Outputs Form C
Voltage outputs (0 to 10 VDC)	yes	-	-	-
Digital outputs	-	yes	yes	yes
Digital pulsed outputs	-	yes	yes	yes
PWM outputs	-	yes	yes	yes
Tristate outputs	-	yes	yes	-
Tristate pulsed outputs	-	yes	yes	-

Universal inputs/outputs

The universal inputs/outputs are ideal for any mix of temperature, pressure, flow, status points, and similar point types in a building control system.

As counter inputs, the universal inputs/outputs are commonly used in energy metering applications. As RTD inputs, they are ideal for temperature points in a building control system. As supervised inputs, they are used for security applications where it is critical to know whether or not a wire has been cut or shorted. These events provide a separate indication of alarms and events in the system.

For all analog inputs, maximum and minimum levels can be defined to automatically detect over-range and under-range values.

The universal inputs/outputs are capable of supporting analog outputs of type voltage outputs. Therefore, the universal inputs/outputs support a wide range of devices, such as actuators.

Solid-state relay outputs

The solid-state relay (SSR) outputs can be used in many applications to switch 24 VAC or 24 VDC on or off for external loads such as actuators, relays, or indicators. SSRs are silent and are not adversely affected by relay contact wear.

Relay outputs

The relay outputs support digital Form A point types. The Form A relays are designed for direct load applications.

High power relay output

The high power relay output is of type Form C. The normally-open (NO) contact is ideal for switching resistive loads of up to 12 A, such as electrical heating elements. The normally-closed (NC) contact can be used to switch inductive loads of up to 3 A.

Optional covers

All RP-C models can be equipped with optional covers to reduce access to the screw terminals and wires.

RP-C with equipped with optional covers

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RP-C

SmartX IP Controller

Wireless connectivity

RP-C is a Bluetooth Low Energy (BLE) enabled product. You can use this wireless connectivity option to connect the RP-C with a smartphone or tablet running the eCommission SmartX Controllers mobile application.

Highly available

The SmartX IP controllers support local trends, schedules, and alarms, enabling local operation when the controller is offline or used in standalone applications.

The battery-free power backup of the memory and real-time clock helps prevent data loss and allows seamless and quick recovery after a power disruption.

In WorkStation, you to update the firmware of multiple SmartX IP controllers at the same time and with minimum down time. The EcoStruxure BMS server keeps track of the installed firmware to support backup, restore, and replacement of the controllers and sensors. The server can host controllers of different firmware versions.

Sensor bus for living space sensors

The SmartX IP controllers provide an interface designed for the SmartX Sensor family of living space sensors. The SmartX Sensors offer an efficient way to sense the temperature, humidity, CO_2, and occupancy in a room. The SmartX Sensors are available with different combinations of sensor types and various covers and user interface options, such as touchscreen, setpoint and override buttons, and blank covers.

SmartX Sensors

The sensor bus provides both power and communications for up to four sensors that are daisy-chained using standard Cat 5 (or higher) cables. The maximum number of sensors that can be connected to a controller varies depending on the sensor model and the combination of cover and sensor base type:

- Blank covers: Up to four sensors of any combination of sensor base types
- 3-button and touchscreen covers:
  - Up to two sensor bases with CO_2 option
  - Up to four sensor bases without CO_2 option
- SmartX LCD temperature sensors: Up to four sensors are supported

The maximum total length of the sensor bus is 61 m (200 ft). For more information, see the SmartX Living Space Sensors Specification Sheet.

Room bus for future support of connected room solutions

The Room bus means the RP-C is hardware-prepared for future support of connected room solutions that include equipment for control of electric lights, window blinds.

Mobile commissioning application

The eCommission SmartX Controllers mobile application is designed for local configuration, field deployment, and commissioning of SmartX IP controllers. The mobile application reduces the commissioning time, allows flexibility in project execution, and minimizes dependencies on network infrastructure.

The mobile application is designed for use with Android, Apple (iOS), and Microsoft Windows 10 devices. For more information, see the eCommission SmartX Controllers Specification Sheet.

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RP-C

SmartX IP Controller

eCommission SmartX Controllers mobile app

Using the eCommission SmartX Controllers mobile application, you can connect to one or many RP-Cs. You can connect to a single RP-C using the controller's built-in Bluetooth connectivity or using the eCommission Bluetooth Adapter connected to a SmartX Sensor. Using a wireless access point or a network switch, you can connect to a network of RP-Cs on the local IP network.

Device configuration

With the eCommission SmartX Controllers mobile application, you can easily discover SmartX IP controllers on the IP network. You can change the configuration of each controller, including the BACnet and IP network settings, location, and parent server. To save engineering time, you can save common device settings and then reuse them for controllers of the same model.

Field deployment and I/O checkout

The eCommission SmartX Controllers mobile application does not require an EcoStruxure BMS server or a network infrastructure to be in place. You can use the mobile application to load the controller application directly into the local SmartX IP controller and deploy the controller. The controller application can be created offline using Project Configuration Tool or WorkStation. You can use the mobile application to change the behavior of an installed standard controller application, such as configuring temperature setpoints. You can also perform an I/O checkout to verify that the controller's I/O points are configured, wired, and operating correctly.

Full EcoStruxure Building Operation software support

The power of the RP-C controller is fully realized when it is part of an EcoStruxure BMS, which provides the following benefits:

- WorkStation/WebStation interface
- Script and Function Block programming options
- Device discovery
- Engineering efficiency
- Preconfigured HVAC applications

WorkStation/WebStation interface

WorkStation and WebStation provide a consistent user experience regardless of which EcoStruxure BMS server the user is logged on to. The user can log on to the parent EcoStruxure BMS server to engineer, commission, supervise, and monitor the SmartX IP controller and its I/O as well as its attached SmartX Sensors. For more information, see the WorkStation and WebStation specification sheets.

Script and Function Block programming options

The freely programmable RP-C controller models have both Script and Function Block programming options. Existing programs can easily be reused between the EcoStruxure BMS server and the controller.

Device discovery

The enhanced Device Discovery in WorkStation enables you to easily identify SmartX IP controllers on a BACnet network and to associate the controllers with their parent server.

Engineering efficiency

The engineering and maintenance of SmartX IP controllers can be done very efficiently using the EcoStruxure Building Operation reusability features. With these features, you can create library items (Custom Types) for a complete controller application that contains programs and all necessary objects such as trends, alarms, and schedules. The controller application in the Custom Types library is reusable across all controllers of the same model. You can use the controller application as a base for creating new controllers intended for similar applications. You can then edit the controller application, and the changes are automatically replicated to all controllers, while each controller keeps its local values.

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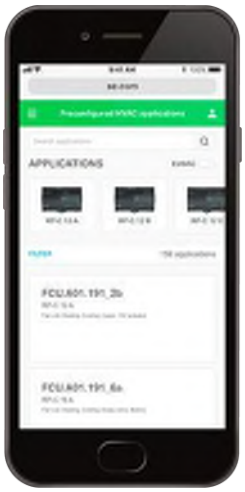
SmartX IP Controller

WorkStation supports both online and offline engineering of SmartX IP controllers. You can make the configuration changes online or use database mode to make the changes offline. In database mode, the changes are saved to the EcoStruxure Building Operation database so that you can apply the changes to the controllers later.

Project Configuration Tool enables you to perform all the engineering off site, without the need for physical hardware, which minimizes the time you need to spend on site. You can run the EcoStruxure BMS servers virtually and engineer the SmartX IP controllers before you deploy your server and controller applications to the servers and controllers on site. For more information, see the Project Configuration Tool specification sheet.

Preconfigured HVAC applications

To improve engineering efficiency and standardize engineering practices, fully designed and tested HVAC applications are available at ecobuilding.schneider-electric.com/design/apps-selector for use with RP-C. This library contains applications for different RP-C models and application types, such as fan coil units and ceiling solutions. These preconfigured HVAC applications are packages that include all software programs, graphics, alarms, and documentation such as functional specifications and I/O wiring schedules needed for your projects. The online repository can be accessed using common web browsers on Windows PCs as well as mobile devices running Apple iOS 11.3 (or later) and Android 6.0 Marshmallow (or later). The download page provides an application selector to help you download an application that meets the needs for a specific room solution with regards to application type, actuator type, fan control type, and sensor type. You can search and view the applications without having to log on to the online repository. To download or email an application, you need to log on or have a valid subscription through single sign-on via a Schneider Electric Exchange account. Before you make your choice, you can view all assets included in the application package. You can download or email an export file, an image file, a selection of the available files, or the whole package. The export file is used when you deploy RP-C from WorkStation, while the image file is used when you deploy RP-C from the eCommission SmartX Controllers mobile app (version 1.4 or later). Subscribe to the application to get a notification when the application is updated.



Download page application selector

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RP-C

SmartX IP Controller

Part Numbers

Product	Part number
RP-C-12A-F-24V	SXWRCF12A10001
RP-C-12B-F-24V	SXWRCF12B10001
RP-C-12C-F-24V	SXWRCF12C10001
RP-C-16A-F-230V	SXWRCF16A10002
Optional covers	SXWRPCCOV10001
DIN-RAIL-CLIP, DIN-rail end clip package of 25 pieces	SXWDINEND10001
eCommission Bluetooth Adapter	SXWBTAECXX10001

Specifications

AC input

RP-C-12A, -12B, and -12C models

Nominal voltage.....24 VAC
Operating voltage range.....+/-15 %
Frequency.....50/60 Hz
Maximum power consumption.....23 VA
Power input protection.....MOV suppression and internal fuse

RP-C-16A model

Nominal voltage.....230 VAC
Operating voltage range.....+/-10 %
Frequency.....50/60 Hz
Maximum power consumption.....65 VA
Power input protection.....MOV suppression and internal fuse
.....Separate PTC thermistor used as a resettable fuse for 24 VAC Out only
Overvoltage category.....III
Pollution degree.....2

DC input

RP-C-12A, -12B, and -12C models

Nominal voltage.....24 to 30 VDC
Operating voltage range.....21 to 33 VDC
Maximum power consumption..... 14 W
Power input protection.....MOV suppression and internal fuse

AC output

RP-C-16A model

Type.....Isolated output

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RP-C

SmartX IP Controller

Nominal voltage.....24 VAC
Frequency..... Same frequency as the power supply (50/60 Hz)
Output power rating .....19 VA

Environment

RP-C-12A, -12B, and -12C models

Ambient temperature, operating .....0 to 50 °C (32 to 122 °F) at normal operation
.....-40 to +60 °C (-40 to +140 °F) for rooftop applications, horizontal installation only
Ambient temperature, storage .....-20 to +70 °C (-4 to +158 °F)
Maximum humidity.....95 % RH non-condensing

RP-C-16A model

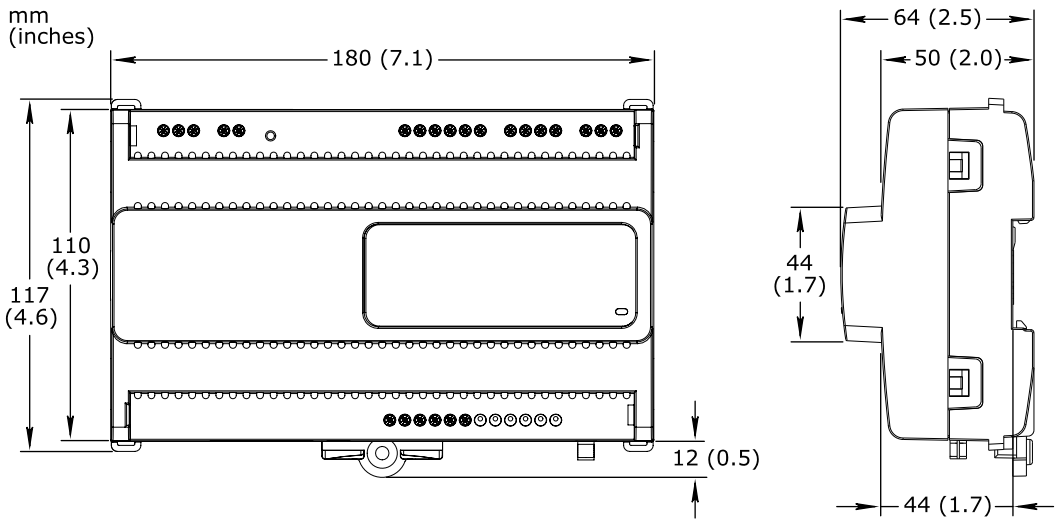
Ambient temperature, operating .....0 to 50 °C (32 to 122 °F)
Ambient temperature, storage .....-20 to +70 °C (-4 to +158 °F)
Maximum humidity.....95 % RH non-condensing

Material

Plastic flame rating.....UL94-5VB
Ingress protection rating .....IP 20

Mechanical

Dimensions..... 180 W x 110 H x 64 D mm (7.1 W x 4.3 H x 2.5 D in.)



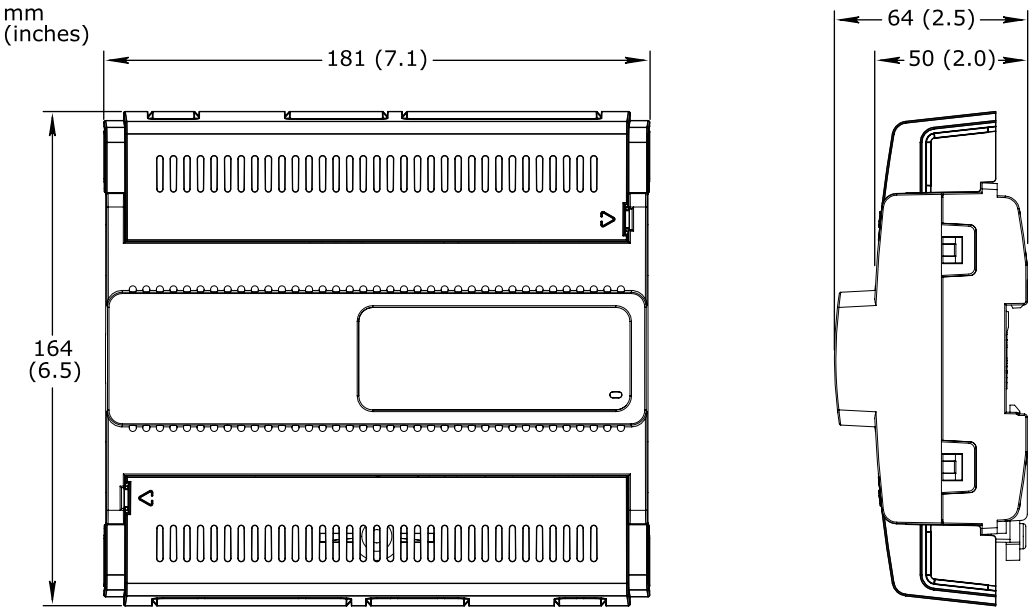
Weight, RP-C-12A model.....0.370 kg (0.816 lb)
Weight, RP-C-12B and -12C models .....0.390 kg (0.860 lb)
Weight, RP-C-16A model.....0.720 kg (1.587 lb)
Weight, optional covers .....0.070 kg (0.154 lb)
Installation .....DIN rail or flat surface
Terminal blocks.....Fixed

RP-C

SmartX IP Controller

Optional covers

Dimensions..... 181 W x 164 H x 64 D mm (7.1 W x 6.5 H x 2.5 D in.)



Software compatibility

EcoStruxure Building Operation software .....version 3.0 or later

Agency compliances

RP-C-12A, -12B, and -12C models

Emission .....RCM; EN 61000-6-3; EN 50491-5-2; FCC Part 15, Sub-parts A and C, Class B

Immunity .....EN 61000-6-2; EN 50491-5-3

Radio.....EN 300 328 V2.1.1

Safety standards.....EN 60730-1; EN 60730-2-11; EN 50491-3; UL 916 C-UL US Listed[a]
a) RP-C-12A is marked “Energy Management Equipment”. RP-C-12B and -12C are marked “Open Energy Management Equipment”.

FCC ID.....DVE-RPC24

ISED certification number .....IC: 24775-RPC24

Fire performance in air-handling spaces[a] ..... UL 2043
a) The RP-C-12A, -12B, and -12C models are approved for plenum applications.

RP-C-16A model

Emission .....RCM; EN 61000-6-3; EN 50491-5-2

Immunity .....EN 61000-6-2; EN 50491-5-3

Radio.....EN 300 328 V2.1.1

Safety standards .....EN 60730-1; EN 60730-2-11; EN 50491-3

Energy .....eu.bac Certified Product (Pending); EN 15500

Real-time clock

Accuracy, at 25 °C (77 °F) .....+/-1 minute per month

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SmartX IP Controller

Backup time, at 25 °C (77 °F) ..... 7 days

Communication ports

Ethernet ..... Dual 10/100BASE-TX (RJ45)
USB ..... 1 USB 2.0 device port (mini-B)
..... 1 USB 2.0 host port (type-A), 5 VDC, 2.5 W
Sensor Bus ..... 24 VDC, 2 W, RS-485 (RJ45)
Sensor Bus protection ..... Transient voltage suppressors on communication and power signals
Room Bus ..... 24 VDC, 3 W, RS-485 (RJ45)
Room Bus protection ..... Transient voltage suppressors on communication and power signals

Communications

BACnet ..... BACnet/IP, port configurable, default 47808
..... BTL B-AAC (BACnet Advanced Application Controller)[a]
a) See the BTL Product Catalog for up-to-date details on BTL listed firmware revisions on BACnet International's home page.

Wireless connectivity

Bluetooth Low Energy

Communication protocol ..... Bluetooth® 5.0 Low Energy compliant
Frequency ..... 2.402 to 2.480 GHz
Maximum output power ..... 10 dBm
Maximum communication distance ..... Line-of-sight: 100 m (328 ft)
Antenna ..... Integrated antenna
RF connector for optional external antenna ..... SMA connector
External antenna (optional) ..... Restricted to the approved antenna type listed below (used in certification)

Manufacturer	Model (Part number)	Gain	Type	Impedance
Linx Technologies	ANT-2.4-WRT-MON-SMA	0.8 dBi	Monopole	50 ohm

CPU

Frequency ..... 500 MHz
Type ..... ARM Cortex-A7 single-core
Internal SRAM ..... 6 MB
NOR flash memory ..... 32 MB
Memory backup ..... 128 kB, FRAM, non-volatile

Universal inputs/outputs

Channels, RP-C-12A model ..... 8 Ub, Ub1 to Ub8
Channels, RP-C-12B model ..... 8 Ub, Ub1 to Ub8
Channels, RP-C-12C model ..... 4 Ub, Ub1 to Ub4
Channels, RP-C-16A model ..... 8 Ub, Ub1 to Ub8
Absolute maximum ratings ..... -0.5 to +24 VDC
A/D converter resolution ..... 16 bits

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SmartX IP Controller

Universal input/output protection.....Transient voltage suppressor on each universal input/output

Digital inputs

Range.....Dry contact switch closure or open collector/open drain, 24 VDC, typical wetting current 2.4 mA
Minimum pulse width.....150 ms

Counter inputs

Range.....Dry contact switch closure or open collector/open drain, 24 VDC, typical wetting current 2.4 mA
Minimum pulse width.....20 ms
Maximum frequency.....25 Hz

Supervised inputs

5 V circuit, 1 or 2 resistors
Monitored switch combinations.....Series only, parallel only, and series and parallel
Resistor range.....1 to 10 kohm
For a 2-resistor configuration, each resistor must have the same value +/- 5 %

Voltage inputs

Range.....0 to 10 VDC
Accuracy.....+/-(7 mV + 0.2 % of reading)
Resolution.....1.0 mV
Impedance.....100 kohm

Current inputs

Range.....0 to 20 mA
Accuracy.....+/-(0.01 mA + 0.4 % of reading)
Resolution.....1 µA
Impedance.....47 ohm

Resistive inputs

10 ohm to 10 kohm accuracy.....$+/-(7 + 4 \times 10^{-3} \times R)$ ohm
R = Resistance in ohm

10 kohm to 60 kohm accuracy.....$+/-(4 \times 10^{-3} \times R + 7 \times 10^{-8} \times R^2)$ ohm
R = Resistance in ohm

Temperature inputs (thermistors)

Range.....-50 to +150 °C (-58 to +302 °F)

Supported thermistors

Honeywell.....20 kohm
Type I (Continuum).....10 kohm
Type II (I/NET).....10 kohm
Type III (Satchwell).....10 kohm
Type IV (FD).....10 kohm
Type V (FD w/ 11k shunt).....Linearized 10 kohm
Satchwell D?T.....Linearized 10 kohm
Johnson Controls.....2.2 kohm

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SmartX IP Controller

Xenta.....1.8 kohm
Balco.....1 kohm

Measurement accuracy

20 kohm.....-50 to -30 °C: +/-1.5 °C (-58 to -22 °F: +/-2.7 °F)
.....-30 to 0 °C: +/-0.5 °C (-22 to +32 °F: +/-0.9 °F)
..... 0 to 100 °C: +/-0.2 °C (32 to 212 °F: +/-0.4 °F)
.....100 to 150 °C: +/-0.5 °C (212 to 302 °F: +/-0.9 °F)

10 kohm, 2.2 kohm, and 1.8 kohm.....-50 to -30 °C: +/-0.75 °C (-58 to -22 °F: +/-1.35 °F)
.....-30 to +100 °C: +/-0.2 °C (-22 to +212 °F: +/-0.4 °F)
.....100 to 150 °C: +/-0.5 °C (212 to 302 °F: +/-0.9 °F)

Linearized 10 kohm .....-50 to -30 °C: +/-2.0 °C (-58 to -22 °F: +/-3.6 °F)
.....-30 to 0 °C: +/-0.75 °C (-22 to +32 °F: +/-1.35 °F)
..... 0 to 100 °C: +/-0.2 °C (32 to 212 °F: +/-0.4 °F)
.....100 to 150 °C: +/-0.5 °C (212 to 302 °F: +/-0.9 °F)

1 kohm .....-50 to +150 °C: +/-1.0 °C (-58 to +302° F: +/-1.8 °F)

RTD temperature inputs

Supported RTDs .....Pt1000, Ni1000, and LG-Ni1000

Pt1000

Sensor range.....-50 to +150 °C (-58 to +302 °F)

SmartX IP Controller device environment	Sensor range	Measurement accuracy
0 to 50 °C (32 to 122 °F)	-50 to +70 °C (-58 to +158 °F)	+/-0.5 °C (+/-0.9 °F)
0 to 50 °C (32 to 122 °F)	70 to 150 °C (158 to 302 °F)	+/-0.7 °C (+/-1.3 °F)
-40 to +60 °C (-40 to +140 °F)	-50 to +150 °C (-58 to +302 °F)	+/-1.0 °C (+/-1.8 °F)

Ni1000

Sensor range.....-50 to +150 °C (-58 to +302 °F)

SmartX IP Controller device environment	Sensor range	Measurement accuracy
0 to 50 °C (32 to 122 °F)	-50 to +150 °C (-58 to +302 °F)	+/-0.5 °C (+/-0.9 °F)
-40 to +60 °C (-40 to +140 °F)	-50 to +150 °C (-58 to +302 °F)	+/-0.5 °C (+/-0.9 °F)

LG-Ni1000

Sensor range.....-50 to +150 °C (-58 to +302 °F)

SmartX IP Controller device environment	Sensor range	Measurement accuracy
0 to 50 °C (32 to 122 °F)	-50 to +150 °C (-58 to +302 °F)	+/-0.5 °C (+/-0.9 °F)
-40 to +60 °C (-40 to +140 °F)	-50 to +150 °C (-58 to +302 °F)	+/-0.5 °C (+/-0.9 °F)

RTD temperature wiring

Maximum wire resistance.....20 ohm/wire (40 ohm total)
Maximum wire capacitance.....60 nF

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SmartX IP Controller

The wire resistance and capacitance typically corresponds to a 200 m wire.

Voltage outputs

Range ..... 0 to 10 VDC
Accuracy ..... +/-60 mV
Resolution ..... 10 mV
Minimum load resistance ..... 5 kohm
Load range ..... -1 to +2 mA

Relay outputs, DO

Channels, RP-C-12A model 0
Channels, RP-C-12B model ..... 3, DO1 to DO3
Channels, RP-C-12C model ..... 3, DO5 to DO7
Channels, RP-C-16A model ..... 3, DO5 to DO7
Contact rating ..... Pilot Duty (C300)
..... Resistive load: 250 VAC/30 VDC, 4 A (cos phi = 1)
..... Inductive load: 250 VAC/30 VDC, 4 A (cos phi = 0.4)
Switch type ..... Form A Relay
..... Single Pole Single Throw
..... Normally Open
Commons ..... COM1 for DO1, DO2, and DO3 (on RP-C-12B model)
..... COM3 for DO5, DO6, and DO7 (on RP-C-12C and RP-C-16A models)
Isolation contact to system ground ..... 3,000 VAC
Cycle life ..... At least 100,000 cycles
Minimum pulse width ..... 100 ms

High power relay outputs, DO

Channels, RP-C-12A model 0
Channels, RP-C-12B model 1, DO4
Channels, RP-C-12C model 1, DO8
Channels, RP-C-16A model 1, DO8
Contact rating ..... Pilot Duty (B300)
..... Minimum current: 100 mA (5 VDC)
..... Normally Open contact, resistive load: 250 VAC/24 VDC, 12 A (cos phi = 1)
..... Normally Closed contact, inductive load: 250 VAC/24 VDC, 3 A (cos phi = 0.4)
Switch type ..... Form C Relay
..... Single Pole Double Throw
..... Normally Open and Normally Closed
Isolation contact to system ground ..... 5,000 VAC
Cycle life ..... At least 100,000 cycles
Minimum pulse width ..... 100 ms

Solid-state relay outputs, DO

Channels, RP-C-12A model ..... 4, DO1 to DO4
Channels, RP-C-12B model 0
Channels, RP-C-12C model ..... 4, DO1 to DO4

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RP-C

SmartX IP Controller

Channels, RP-C-16A model ..... 4, DO1 to DO4

Output rating.....Maximum 2 A load per output
.....Maximum 4 A total load for the 4 outputs

AC voltage range .....24 VAC +/-20 %

DC voltage range.....Maximum 30 VDC

Commons .....COM1 for DO1 and DO2 (on RP-C-12A, -12C, and -16A models)
.....COM2 for DO3 and DO4 (on RP-C-12A, -12C, and -16A models)
When the SSR outputs are used to switch AC, the common terminals can be connected to 0 to 30 VAC. When the SSR outputs are used to switch DC, the common terminals can be connected to -30 VDC to +30 VDC.

Common voltage range (AC) .....0 to 30 VAC

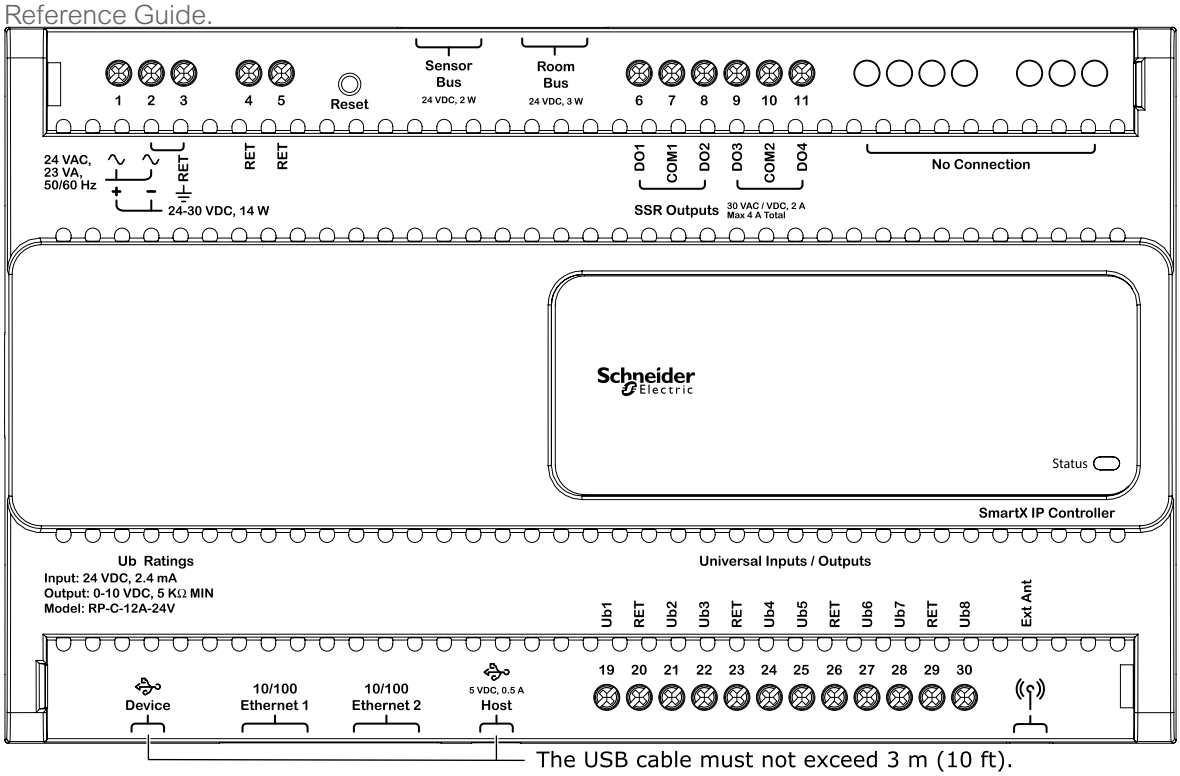
Common voltage range (DC) .....-30 to +30 VDC

Minimum pulse width .....100 ms

Solid-state relay output protection .....Transient voltage suppressor across each solid-state relay (SSR) output

Terminals

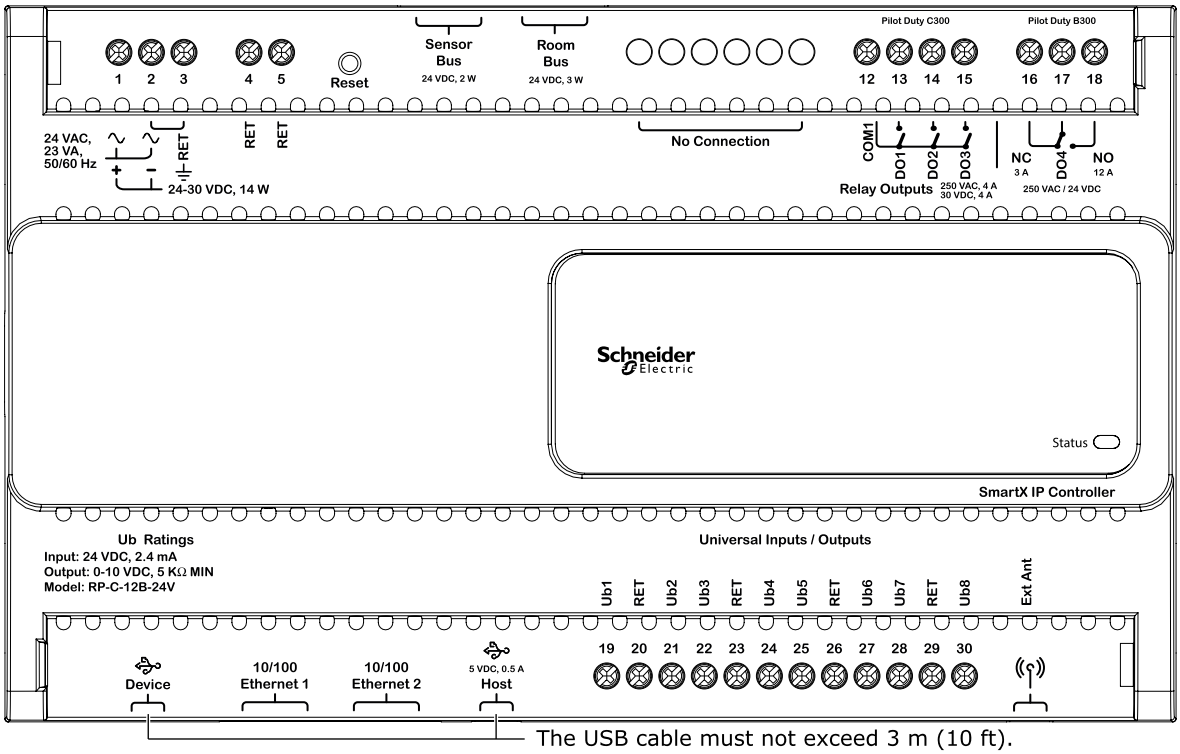
For more information on wiring, see Hardware Reference Guide.



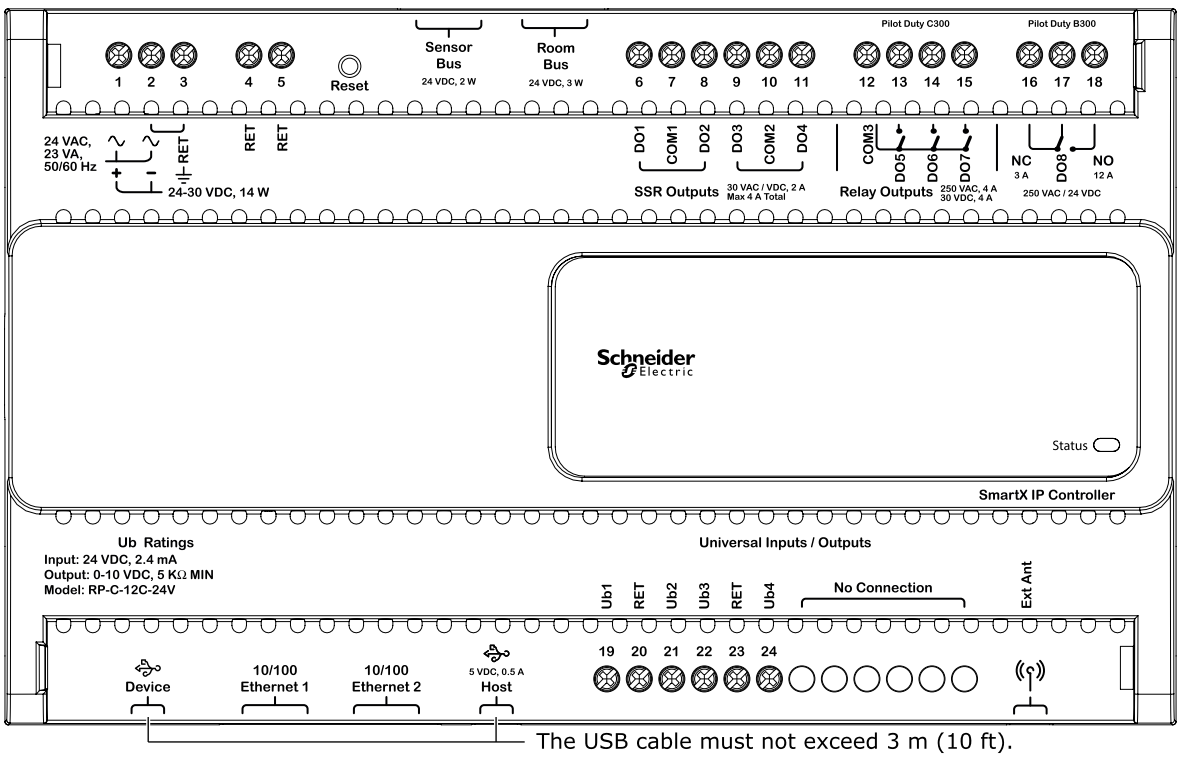
RP-C-12A model (24 VAC/DC)

RP-C

SmartX IP Controller



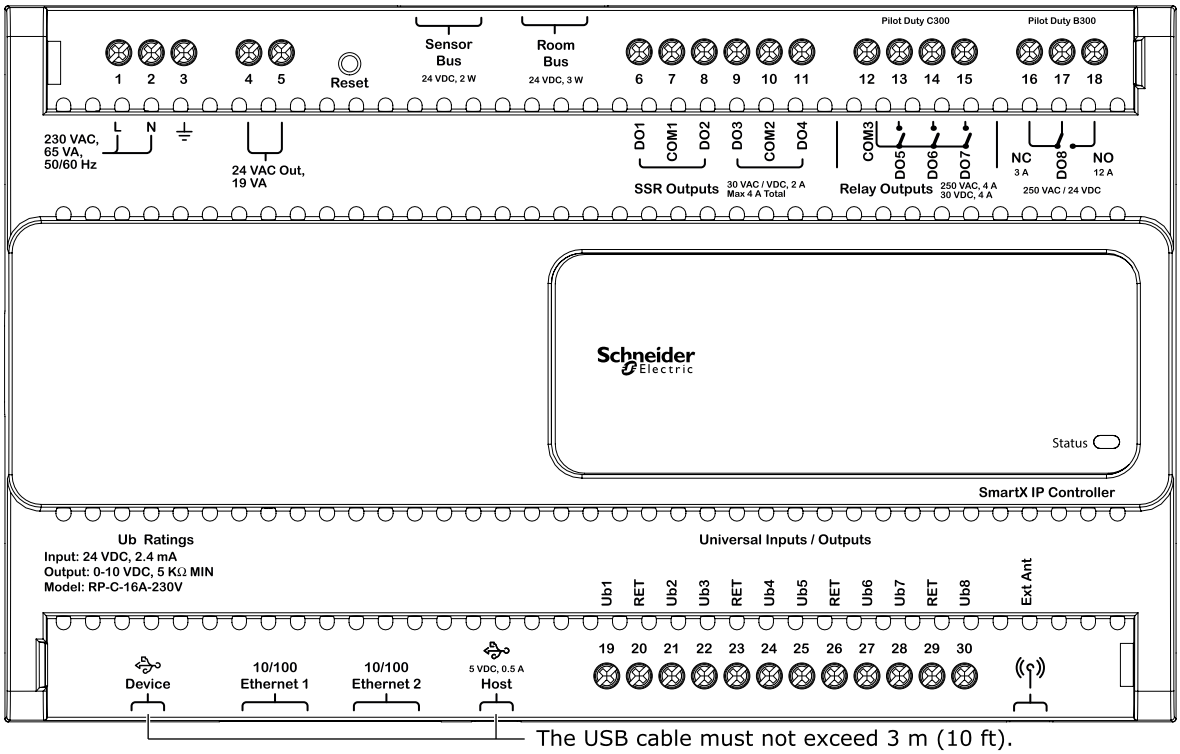
RP-C-12B model (24 VAC/DC)



RP-C-12C model (24 VAC/DC)

RP-C

SmartX IP Controller



RP-C-16A model (230 VAC)

Part Numbers in AMER Region for Network Connectivity Accessories

Product description[a]	Part number (AMER region)
Cat 6 field-term plug, UTP	ACTPG6TLU001
Cat 6 pass-through plug, UTP, 100-pack	ACTPG6PTU100
Actassi crimping tool	ACTTLCPT
Cat 6 cable, UTP, 1000 ft (305 m), CMP, green	ACT4P6UCP1ARXGR
Cat 6 patch cord, UTP, 30 ft (9 m), CMP, green	ACTPC6UBCP30AGR
Cat 6 patch cord, UTP, 50 ft (15 m), CMP, green	ACTPC6UBCP50AGR
Cat 6 patch cord, UTP, 70 ft (21 m), CMP, green	ACTPC6UBCP70AGR
Cat 6 patch cord, UTP, 90 ft (27 m), CMP, green	ACTPC6UBCP90AGR
Cat 5e pass-through plug, UTP, 100-pack	ACTPG5EPTU100
Cat 5e cable, UTP, 1000 ft (305 m), CMP, green	ACT4P5EUCP1ARXGR
Cat 5e patch cord, UTP, 30 ft (9 m), CMP, green	ACTPC5EUBCP30AGR
Cat 5e patch cord, UTP, 50 ft (15 m), CMP, green	ACTPC5EUBCP50AGR
Cat 5e patch cord, UTP, 70 ft (21 m), CMP, green	ACTPC5EUBCP70AGR
Cat 5e patch cord, UTP, 90 ft (27 m), CMP, green	ACTPC5EUBCP90AGR

a) For more information, see the Product Selection Guide (SmartX IP Controllers - Accessories). Abbreviations: UTP (Unshielded Twisted Pair), CMP (Plenum-rated cable)

RP-C
SmartX IP Controller

Part Numbers in EMEA Region for Network Connectivity Accessories

Product description[a]	Part number (EMEA region)
Cat 6 field-term plug, UTP	ACTPG6TLU001
Cat 6 pass-through plug, UTP, 100-pack	ACTPG6PTU100
Actassi crimping tool	ACTTLCPT
Cat 6 cable, UTP, 305 m (1000 ft), Euroclass D, green	VDICD116118
Cat 6 patch cord, UTP, 10 m (32 ft), LSZH, green	ACTPC6UBLS100GR
Cat 6 patch cord, UTP, 15 m (49 ft), LSZH, green	ACTPC6UBLS150GR
Cat 6 patch cord, UTP, 20 m (65 ft), LSZH, green	ACTPC6UBLS200GR
Cat 6 patch cord, UTP, 25 m (82 ft), LSZH, green	ACTPC6UBLS250GR
Cat 5e pass-through plug, UTP, 100-pack	ACTPG5EPTU100
Cat 5e cable, UTP, 1000 ft (305 m), Euroclass D, green	VDICD115118
Cat 5e patch cord, UTP, 10 m (32 ft), LSZH, green	ACTPC5EUBLS100GR
Cat 5e patch cord, UTP, 15 m (49 ft), LSZH, green	ACTPC5EUBLS150GR
Cat 5e patch cord, UTP, 20 m (65 ft), LSZH, green	ACTPC5EUBLS200GR
Cat 5e patch cord, UTP, 25 m (82 ft), LSZH, green	ACTPC5EUBLS250GR

a) For more information, see the Product Selection Guide (SmartX IP Controllers - Accessories). Abbreviations: UTP (Unshielded Twisted Pair), CMP (Plenum-rated cable), LSZH (Low Smoke Zero Halogen)

Part Numbers in Pacific Region for Network Connectivity Accessories

Product description[a]	Part number (Pacific region)
Cat 6 field-term plug, UTP	ACTPG6TLU001
Cat 6 pass-through plug, UTP, 100-pack	ACTPG6PTU100
Actassi crimping tool	ACTTLCPT
Cat 6 cable, UTP, 305 m (1000 ft), PVC, green	2D4P6IPV3B-GR
Cat 6 patch lead, UTP, 10 m (32 ft), PVC, green	RJ6_100PL-GR
Cat 6 patch lead, UTP, 15 m (49 ft), PVC, green	RJ6_150PL-GR
Cat 6 patch lead, UTP, 20 m (65 ft), PVC, green	RJ6_200PL-GR
Cat 6 patch lead, UTP, 25 m (82 ft), PVC, green	RJ6_250PL-GR
Cat 5e pass-through plug, UTP, 100-pack	ACTPG5EPTU100
Cat 5e cable, UTP, 305 m (1000 ft), PVC, green	2D4P5IPV3B-GR
Cat 5e patch lead, UTP, 10 m (32 ft), PVC, green	RJ5_100PL-GR
Cat 5e patch lead, UTP, 15 m (49 ft), PVC, green	RJ5_150PL-GR
Cat 5e patch lead, UTP, 20 m (65 ft), PVC, green	RJ5_200PL-GR
Cat 5e patch lead, UTP, 25 m (82 ft), PVC, green	RJ5_250PL-GR

a) For more information, see the Product Selection Guide (SmartX IP Controllers - Accessories). Abbreviations: UTP (Unshielded Twisted Pair), PVC (Polyvinyl chloride)

03-30017-01-en, April 2019

RP-C

SmartX IP Controller

Regulatory Notices

Federal Communications Commission
FCC Rules and Regulations CFR 47, Part 15, Class B
This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference. (2) This device must accept any interference received, including interference that may cause undesired operation.
FCC ID: DVE-RPC24

Industry Canada
This Class B digital apparatus complies with Canadian ICES-003.
Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.
IC: 24775-RPC24

Regulatory Compliance Mark (RCM) - Australian Communications and Media Authority (ACMA)
This equipment complies with the requirements of the relevant ACMA standards made under the Radiocommunications Act 1992 and the Telecommunications Act 1997. These standards are referenced in notices made under section 182 of the Radiocommunications Act and 407 of the Telecommunications Act.

eu.bac - European Building Automation and Controls Association. Certified Product (Pending).
This product is certified by eu.bac and conforms to the quality and energy performance criteria outlined by the following European product standard: EN 15500.
All eu.bac certified products are found on the eu.bac web site www.eubaccert.eu

CE - Compliance to European Union (EU)
2014/53/EU Radio Equipment Directive (RED)
2014/35/EU Low Voltage Directive
2011/65/EU Restriction of Hazardous Substances (RoHS) Directive
2015/863/EU amending Annex II to Directive 2011/65/EU
This equipment complies with the rules, of the Official Journal of the European Union, for governing the Self Declaration of the CE Marking for the European Union as specified in the above directive(s) per the provisions of the following standards: EN 60730-1, EN 60730-2-11, and EN 50491-3 Safety Standards.

WEEE - Directive of the European Union (EU)
This equipment and its packaging carry the waste of electrical and electronic equipment (WEEE) label, in compliance with European Union (EU) Directive 2012/19/EU, governing the disposal and recycling of electrical and electronic equipment in the European community.

UL 916 Listed products for the United States and Canada. UL file E80146.

03-30017-01-en, April 2019

ET Series

SPECIFICATIONS

	For TAC Vista, I/NET, Continuum, and I/A	1000 Ohm Platinum	1000 Ohm BALCO
Output	1.8K Ohms @ 77° F (25° C) Vista 10K Ohms @ 77° F (25° C) I/Net 10K Ohms @ 77° F (25° C) Continuum 10K Ohms @ 77° F (25° C) with 11K Ohms shunt resistor I/A	1K Ohms @ 32°F (0°C)	1000 Ohms @ 70°F (21°C)
Temperature Range	-40° to 302° F (-40° to 150° C)	-58° to 392°F (-50 to 200°C) -50° to 275°F (-45.5° to 134.8°C)	-40° to 240°F (-40° to 116°C)
Interchangeability	+/- 0.2 C (0° to 70° C)		
Temperature Coefficient		0.00385 Ohm/Ohm/°C	2.2 Ohms/°F
Dissipation Constant Stability	3 mW / C		
Accuracy	+/- 0.2° C (0° to 70° C) +/- 0.4° F (32° to 158° C)	+/- 0.06% @ 32°F (0°C) Single Point +/- 1.0 Ohm @ 70°F (Averaging)	+/- 0.1%
Operating Humidity	0 to 90% RH non-condensing		

Application

Thermistors offer high accuracy and interchangeability over a wide temperature range. The ET series can be used in the following applications:

- Space
- Duct
- Immersion
- Averaging
- Strap-On
- Bead/Bullet
- Outdoor Air

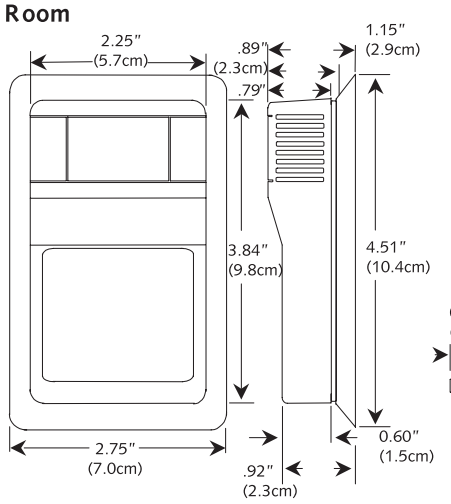
Features

- Offer high accuracy and interchangeability over a wide temperature range.
- Non-polarity sensitive

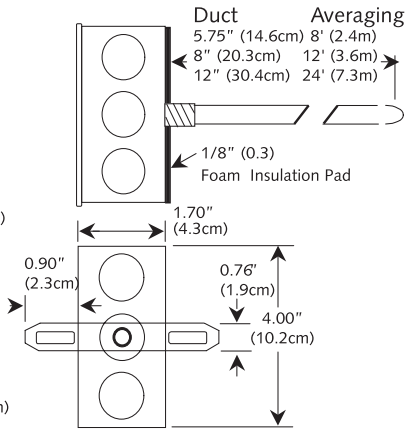
Schneider Electric

DIMENSIONS

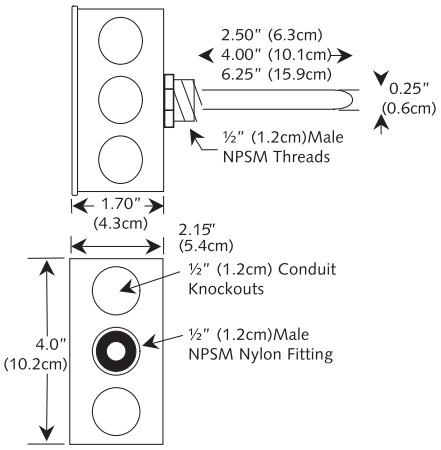
Room



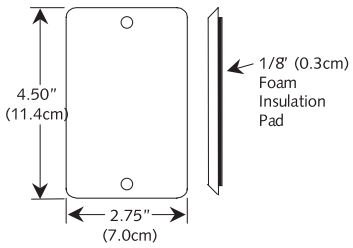
Duct / Averaging



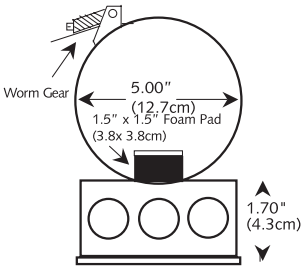
Immersion



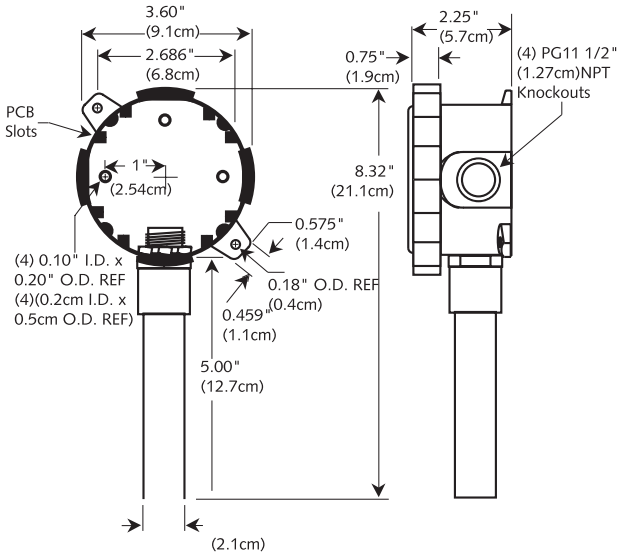
Stainless Plate



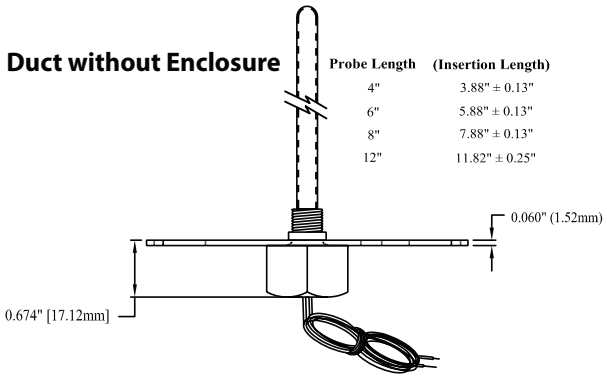
Strap-On



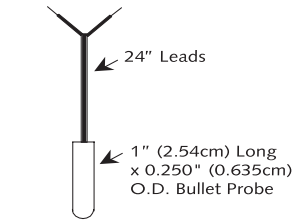
Outside Air



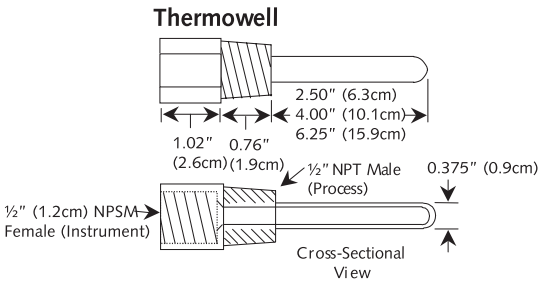
Duct without Enclosure



Bullet Probe



Thermowell



INSTALLATION

Room Temperature Sensors

This unit is suitable for either drywall mounting or junction box mounting. The room sensor is provided with screw terminal blocks for all connections. Remove the cover from the unit and mount the housing base to the wall using the (2) 6/32" x 1" machine screws. Replace the cover and tighten down, using the (2) 1/16" Allen Screws located on the bottom of the enclosure.

Duct and Duct Averaging Sensors

Duct temperature sensors - drill a 3/8" hole in the duct and insert the probe through the hole until the foam pad is tight to the duct. Now insert (2) screws through the mounting holes in flange and tighten them until the unit is held firmly to the duct. Duct Averaging sensors - Drill a 3/8" hole in the duct and insert the averaging element through the hole until the foam pad is tight to the duct. Now insert the (2) screws through the holes in the mounting flange and tighten until the unit is held firmly to the duct. The sensor should then be strung in a criss-cross pattern throughout the duct using the mounting clips provided, in a pattern that covers the greatest surface area of the duct, to insure that there is no stratification. When bending the copper tubing, be careful that you use a gradual bend and that you DO Not kink the copper tubing.

Immersion Temperature Sensors

The Fluid Immersion-type sensors are provided with a 2 ½", 4", or 6 ¼" insertion length, 304 series stainless steel thermowell. The thermowell has a 1/2" NPT external or process thread and a 1/2" NPS Female process thread. Heat transfer compound may be used but it is not necessary.

Strap-On Temperature Sensors

The TAC Strap-On sensors, are provided in a NEMA 1 rated junction box with an adjustable 2" to 5" pipe clamp. The unit should be mounted on the bottom side of the pipe to ensure proper heat transfer and a true temperature reading. Heat transfer compound and insulating the sensor will help the overall accuracy of the sensor. By ordering extra straps, and fastening them together, it is possible to make them fit larger pipes.

Outside Air Temperature Sensors

The TAC Outdoor Air temperature sensors are provided in a weatherproof enclosure. An optional weatherproof Aluminum Bell Box or NEMA 4X Polycarbonate enclosure is also available upon request for an additional charge. All of the mounting hardware is provided with the sensor. Be sure to mount the sensor out of direct sunlight, with the sensor probe pointing downward.

Stainless Plate Temperature Sensors

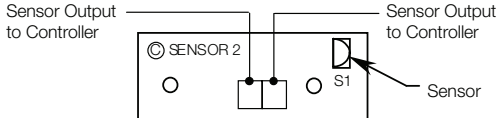
The TAC Stainless Plate temperature sensors are mounted on the back of a 1 Gang stainless steel plate. The foam pad will insulate the sensor from any drafts in the wall. (2) 6/32" x 1" machine screws are provided for junction box mounting. Be sure that the sensor is not mounted on an outside wall, due to the extreme temperature changes from either drafts or heat transfer.

WIRING

For wiring Information on room temperature sensors, please refer to the following documents:

System	F-Number
Vista	F-27616
I/NET	F-27617
Continuum	F-27618
I/A	F-27619

Diagram for ET Sensors Except ETR



ORDERING INFORMATION

Temperature Sensor Description	TAC Vista	I/NET	Continuum	I/A	1000 Ohm Platinum	1000 Ohm BALCO
Room	ETR100	ETR200	ETR500	ETR800	-	-
Room with Setpoint	ETR101	ETR201	ETR501	ETR801	-	-
Room with Override Pushbutton	ETR102	ETR202	ETR502	ETR802	-	-
Room with Setpoint and Override Pushbutton	ETR103	ETR203	ETR503	ETR803	-	-
Wallplate (Stainless Steel)	ETP100	ETP200	ETP500	ETP800		
4” Duct (Galvanized Steel Enclosure)	ETD100-4	ETD200-4	ETD500-4	ETD800-4	ETDPK0-4	ETDBK0-4
6” Duct Galvanized Steel Enclosure)	ETD100-6	ETD200-6	ETD500-6	ETD800-6	ETDPK0-6	ETDBK0-6
8” Duct (Galvanized Steel Enclosure)	ETD100-8	ETD200-8	ETD500-8	ETD800-8	ETDPK0-8	ETDBK0-8
12” Duct (Galvanized Steel Enclosure)	ETD100-12	ETD200-12	ETD500-12	ETD800-12	ETDPK0-12	ETDBK0-12
4” Duct without Enclosure	ETD100-NE-4	ETD200-NE-4	ETD500-NE-4	ETD800-NE-4	ETDPK0-NE-4	ETDBK0-NE-4
6” Duct without Enclosure	ETD100-NE-6	ETD200-NE-6	ETD500-NE-6	ETD800-NE-6	ETDPK0-NE-6	ETDBK0-NE-6
8” Duct without Enclosure	ETD100-NE-8	ETD200-NE-8	ETD500-NE-8	ETD800-NE-8	ETDPK0-NE-8	ETDBK0-NE-8
12” Duct without Enclosure	ETD100-NE-12	ETD200-NE-12	ETD500-NE-12	ETD800-NE-12	ETDPK0-NE-12	ETDBK0-NE-12
2.5” Immersion (Galvanized Steel Enclosure)*	ETI100-2	ETI200-2	ETI500-2	ETI800-2	ETIPK0-2	ETIBK0-2
4” Immersion (Galvanized Steel Enclosure)*	ETI100-4	ETI200-4	ETI500-4	ETI800-4	ETIPK0-4	ETIBK0-4
6.25” Immersion (Galvanized Steel Enclosure)*	ETI100-6	ETI200-6	ETI500-6	ETI800-6	ETIPK0-6	ETIBK0-6
8’ Averaging (Flexible Copper)	ETA100-8	ETA200-8	ETA500-8	ETA800-8	-	-
12’ Averaging (Flexible Copper)	ETA100-12	ETA200-12	ETA500-12	ETA800-12	ETAPK0-12	ETABK0-12
24’ Averaging (Flexible Copper)	ETA100-24	ETA200-24	ETA500-24	ETA800-24	ETAPK0-24	ETABK0-24
Outside Air	ETO100	ETO200	ETO500	ETO800	-	-
Strap On	ETS100	ETS200	ETS500	ETS800	-	-
Bead / Bullet	ETB100	ETB200	ETB500	ETB800	-	-

* Length indicates immersion depth.

Miscellaneous Options	Code
LCD Display in Fahrenheit (for room units only)	-LCD
LED Indicator* (for room units with override only)	-LED
Thermometer Indicator (for room units only)	-TI
RS232 Communication Jack (for use with I/NET systems only)	-RS232
Four-Pin RJ11 Communication Jack (for use with TAC Vista and Continuum systems only)	-RJ4

* Not available on I/A, 1000 Ohm Platinum, or 1000 Ohm BALCO.

Well Type	Part Number
2.5” Stainless Steel Well*	ETI-WELL-2S
4” Stainless Steel Well*	ETI-WELL-4S
6.25” Stainless Steel Well*	ETI-WELL-6S

* Length indicates immersion depth.

EP Series

Differential Pressure/Air Velocity Transducer

Product Description

The EP transducer can measure either air pressure or velocity with the flip of a switch. The EP is available in three installation configurations: duct, panel or universal. Duct and panel models have two pressure and velocity options: 0-1” WC / 0-3,000 ft/min or 1-10” WC / 3,000-6,000 ft/min with four field-selectable sub-ranges. The universal model comes in one pressure/velocity range: 0-10” WC / 0-7,000 ft/min with seven field-selectable sub-ranges for pressure and eight for velocity. All variants are available with and without display. The EP has an IP65/NEMA 4 environmental rating and a 5-year limited warranty.

Features

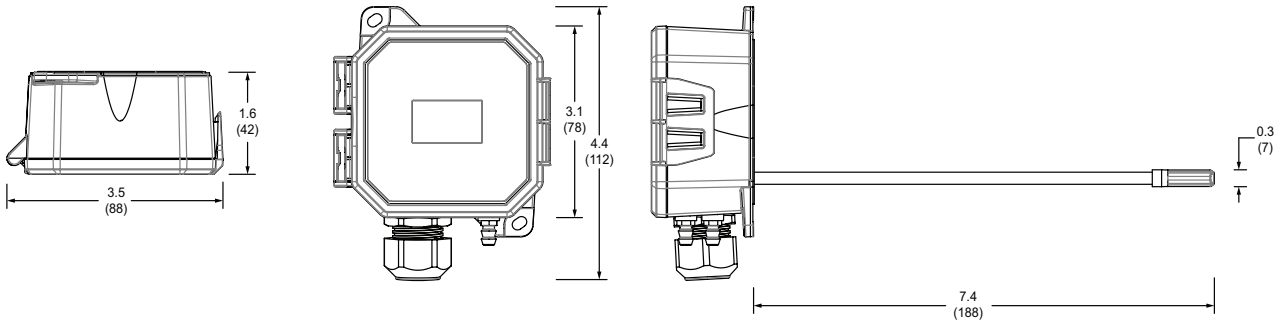
- High reliability sensor technology for long-term, maintenance-free operation
- Seven pressure and eight velocity sub-ranges with three selectable outputs for easy on-the-job setup
- IP65/NEMA 4 housing allows mounting in wash-down locations
- Circuit protection avoids damage due to incorrect input wiring

Available Products

Enclosure	Range	Local Display
EP □ D = Duct P = Panel	301 = Pressure: 0 to 1 in. WC 0 to 250 Pa Velocity: 0 to 3000 ft/min 0 to 15 m/s 302 = Pressure: 0 to 10 in. WC 0 to 2500 Pa Velocity: 0 to 6000 ft/min 0 to 30 m/s	□ Blank = No Display LCD = LCD Display

Enclosure	Range	Local Display
EP U U = Universal	305 = Pressure: 0 to 10 in. WC 0 to 2500 Pa Velocity: 0 to 7000 ft/min 0 to 35 m/s	□ Blank = No Display LCD = LCD Display

Dimensions in. (mm)



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Specifications

Media Compatibility	Dry or inert gas
Input Power	Three-wire Volt mode: 24 Vac or 12-30 Vdc*, Two-wire mA mode: 12-30 Vdc*
Output Power	Field-selectable: 2-wire, loop-powered 4-20 mA** (DC only, clipped and capped), 24 Vac/dc or 3-wire 0-5V/0-10V***
301 Pressure Range	Pressure mode: Unidirectional: 0.1/0.25/0.5/1.0 in. WC FS, switch selectable Bidirectional: ±0.1/±0.25/±0.5/±1.0 in. WC FS, switch selectable Unidirectional: 25 Pa/50 Pa/100 Pa/250 Pa, FS, switch selectable Bidirectional: ±25 Pa/±50 Pa/±100 Pa/±250 Pa, FS, switch selectable Velocity mode: 500/1,000/2,000/3,000 ft/min, 2.5/5/10/15 m/s
302 Pressure Range	Pressure mode: Unidirectional: 1.0/2.5/5.0/10 in. WC FS, switch selectable Bidirectional: ±1.0/±2.5/±5.0/±10 in. WC FS, switch selectable Unidirectional: 0.250 kPa/0.500 kPa/1.000 kPa/2.500 kPa, FS, switch selectable Bidirectional: ±0.250 kPa/±0.500kPa/±1.000 kPa/±2.500 kPa, FS, switch selectable Velocity mode: 3,000/4,000/5,000/6,000 ft/min, 15/20/25/30 m/s
305 Pressure Range	Pressure mode: Unidirectional: 0.1/0.25/0.5/1.0/2.5/5/10 in. WC FS, switch selectable Bidirectional: ±0.1/0.25/0.5/1.0/2.5/5/10 in. WC FS, switch selectable Unidirectional: 25Pa/50Pa/100Pa/250Pa/0.5kPa/1kPa/2.5kPa FS, switch selectable Bidirectional: ±25Pa/50Pa/100Pa/250Pa/0.5kPa/1kPa/2.5kPa FS, switch selectable Velocity mode: 500/1000/2000/3000/4000/5000/6000/7000 ft/min, 2.5/5/10/15/20/25/30/35 m/s
Response Time	Standard: T95 in 20 sec, Fast: T95 in 2 sec, DIP switch selectable
Mode	Unidirectional or bidirectional, DIP switch selectable
Display (Option)	Pressure mode: Signed 3-1/2 digit LCD, indicates pressure, overrange indicator Velocity mode: Signed 4-1/2 digit LCD, indicates velocity, overrange indicator
Proof Pressure	3 psid (20.6 kPa)
Burst Pressure	5 psid (34.5 kPa)
Pressure Mode Accuracy	±1% FS (combined linearity and hysteresis)
Velocity Mode Accuracy	±90 ft/min (±0.45 m/s) plus 5% of measured value****
Temperature Effect	1” (250 Pa) models: 0.05%/°C; 10” (2.5 kPa) models: 0.01%/°C (Relative to 25 °C) 0 to 50 °C (32 to 122 °F)
Zero Drift (1 year)	1” (250 Pa) models: 2.0% max.; 10” (2.5 kPa) models: 0.5% max.
Zero Adjust	Pushbutton auto-zero and digital input (2-position terminal block)
Operating Environment	0 to 60 °C (32 to 140 °F)
Altitude of Operation	0 to 3000 m
Pollution Degree	2
Humidity Range	100% RH, non-condensing
Mounting Location	For indoor use only.
Fittings	Brass barb; 0.24” (6.1 mm) o.d.
Limited Warranty	5 years
Environmental Rating	IP65, NEMA 4
Flammability Rating	UL 94 5VA fire retardant ABS, plenum rated

EMC Conformance: EN 61000-6-3 and A1 Class B, EN 61000-6-1.
* Class 2/II power source.
** Minimum input voltage for 4 to 20 mA operation: 250 Ω loop = 12 Vdc; 500 Ω loop = 19 Vdc.
*** Minimum load resistance for Volt operation: 5 kΩ.
**** For measured values between 200 and 7000 ft/min (1 and 35 m/s).

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EH Series

Humidity Sensors

Data Sheet

DESCRIPTION

The EH Series Room, Duct and Outside hunidity sensors are a universal Relative Humidity transmitter that can be powered with either a +15 to 36 Vdc or 24 Vac supply voltage. The EH series sensors are designed with a field selectable 4-20 mA, 0-5 VDC, or 0-10 Vdc output signal that is equivalent to 0 to 100% RH. The EH Series is used in building automation systens, humidity chambers, and OEM applications and is compatible with Vista, Continuum, I/Net and I/A Systens.

EH Series

FEATURES

- Single point Field Calibration
- Field selectable output signals
- ±2% Accuracies
- Low Drift
- Highly Repeatable
- Integral Temperature Sensor

SPECIFICATIONS

Supply Voltage	250 Ohm Load: +15 to 36 Vdc / 21.6-26.4 Vac 0-5VDC: +15-36 Vdc / 21.6-26.4 Vac 500 Ohm Load: +18 to 36 Vdc / 21.6-26.4 Vac 0-10VDC: +18-36 Vdc / 21.6-26.4 Vac
Power Consumption	1VA maximum
RH Measurement Range	0 to 100%
RH Output	2-wire, 4 to 20mA (Factory Standard) 3-wire, 0-5, 0-10 Vdc or 4 to 20mA
Accuracy at 77° F (25° C)	+/- 2% from 20 to 95%
Long-term Stability	Less than 2% drift / 5 years
Hysteresis	Less than 0.4% RH
Repeatability	0.5% RH
Sensitivity	0.1 % RH
Response Time	110 seconds for 63% Step
Storage Temperature Range	41 to 95°F (5°C to 35°C) < 75% RH
Operating Temperature Range	-10 to 122°F (-23.3 to 50°C)
Operating Humidity Range	0 to 95 % RH non-condensing
Saturation Response Time	10 minutes for 63% Step
Temperature Sensor output at 77° F (25° C)	1.8K ohm (Vista), 10K ohm Type II (I/Net), 10K ohm Type III (Continuum), 10K ohm with 11K ohm shunt (I/A)

Printed in the U.S.A 6-10

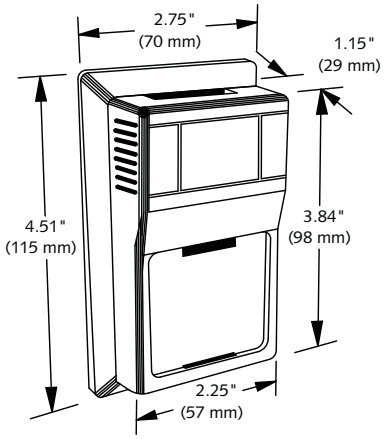
ORDERING INFORMATION

Description	Vista	I/Net	Continuum	I/A
Room-Humidity Only	EHR110			
Room-Humidity and Temperature	EHR110-100	EHR110-200	EHR110-500	EHR110-800
Duct-Humidity Only	EHD110			
Duct-Humidity and Temperature	EHD110-100	EHD110-200	EHD110-500	EHD110-800
Outdoor-Humidity Only	EHO110			
Outdoor-Humidity and Temperature	EHO110-100	EHO110-200	EHO110-500	EHO110-800

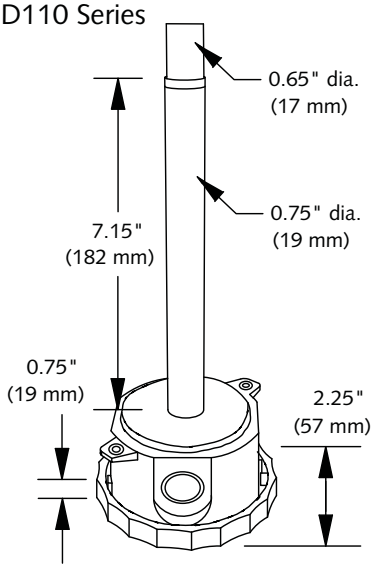
Miscellaneous Option	Code
LCD Display (Room Units Only. LCD displays humidity value.)	-LCD

DIMENSIONS

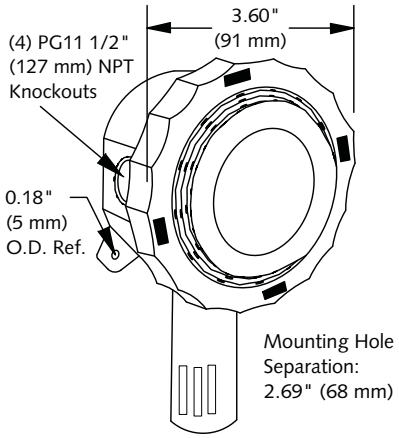
EHR110 Series



EHD110 Series



EHO110 Series



On October 1st, 2009, TAC became the Buildings business of its parent company Schneider Electric. This document reflects the visual identity of Schneider Electric, however there remains references to TAC as a corporate brand in the body copy. As each document is updated, the body copy will be changed to reflect appropriate corporate brand changes.

Schneider Electric
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Loves Park, IL 61132-2940
www.schneider-electric.com/buildings

Hx08 Series & H701


H908


H708


H808


H608


H308

CURRENT SENSING THE ULTIMATE PROOF OF FLOW

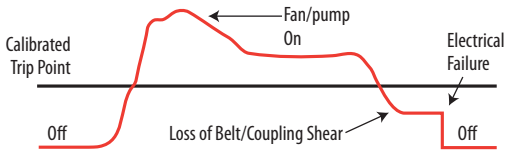
Maximize Reliability
Minimize Installed Cost

SPECIFICATIONS

Sensor Power	Induced from monitored conductor
Insulation Class	600 Vac RMS (UL), 300 Vac RMS (CE1)
Frequency Range	50/60 Hz, on/off status for Variable Frequency Drive (VFD) outputs at 12 to 115 Hz2
Temperature Range	-15 to 60 °C (5 to 140 °F)
Humidity Range	10 to 90% RH, non-condensing
Hysteresis	10% (typical)
Terminal Block Wire Size	H308: 22-16 AWG (0.3 to 1.3 mm2) Others: 24-14 AWG (0.2 to 2.1 mm2)
Terminal Block Torque	H308: 3.5 to 7 in-lbs (0.8 N-m) Others: 3.5 to 4.4 in-lbs (0.4 to 0.5 N-m)
Agency Approvals	UL 508 open device listing; CE: EN61010-1, CAT III, pollution degree 2, basic insulation
Limited Warranty	5 years

1. The CE mark indicates RoHS2 compliance. Please refer to the CE Declaration of Conformity for additional details.
2. VFD systems generate fields that can disrupt electrical devices. Ensure that these fields are minimized and are not affecting the sensor.
Note: Do not use the LED status indicators as evidence of applied voltage.
If using this switch in an application that includes an electronically commutated motor (ECM), see Veris Application Note VN61, at www.veris.com.

DETECTS BELT LOSS/COUPLING SHEAR!



Now you can easily detect when drive belts slip, break, or pump couplings shear. In fact, a typical HVAC motor that loses its load has a reduction of current draw of up to 50%. That's why our sensors are the industry standard for status.

DETECT BELT LOSS, COUPLING SHEAR, AND MECHANICAL FAILURE

DESCRIPTION

Hx08 Series and H701 adjustable current switches offer high performance, with a wide array of amperage range options. These products can accurately detect belt loss, coupling shear, or other mechanical failure on unit vents, exhaust fans, recirculation pumps, and other fixed loads down to as little as 1/5 HP.

APPLICATIONS

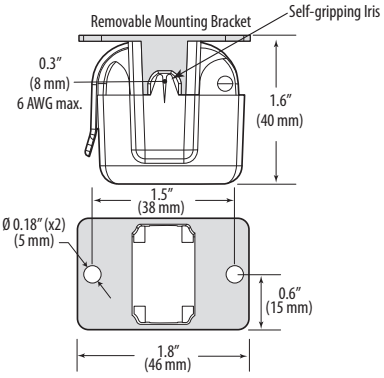
- Detecting belt loss, coupling shear, and mechanical failure
- Verifying lighting circuit and other electrical service run times
- Monitoring status of industrial process equipment
- Monitoring status of critical motors (compressor, fuel, etc.)
- VFD output On/Off status

FEATURES

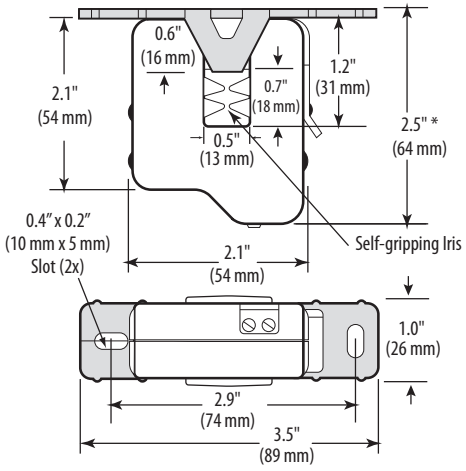
- High performance devices in split- and solid-core housings
- Adjustable trip point...precise current trip point setting
- Minimum trip point as low as 0.5 A (H608)...avoids the need for multiple wraps of the conductor through the sensor even on loads as small as 1/5 HP
- Small size...fits easily inside small enclosures
- Self-gripping iris on split-core housings for easy installation
- Status LEDs available for easy setup and local indication
- Bracket on H908 can be installed in three different configurations...installation flexibility in tight spaces
- 1 Amp status output...increased application flexibility
- All devices are 100% solid state for high reliability and polarity insensitive for trouble-free installation, with a 5-year warranty

DIMENSIONAL DRAWINGS

H308

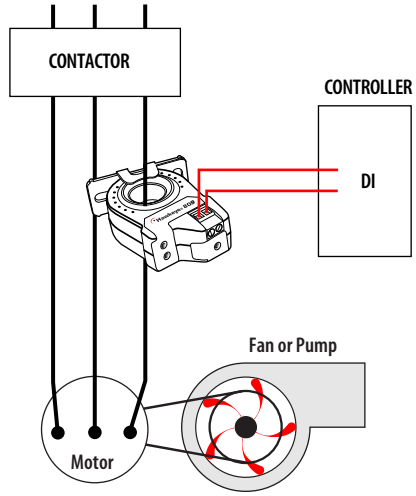


H608

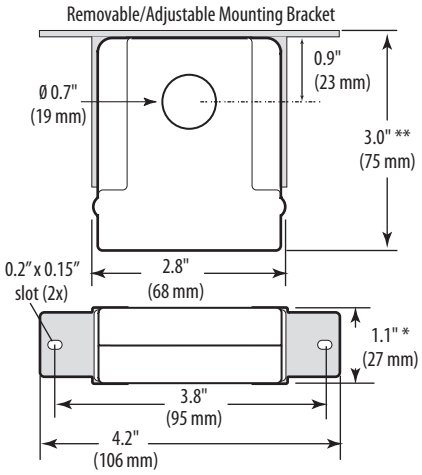


WIRING DIAGRAM

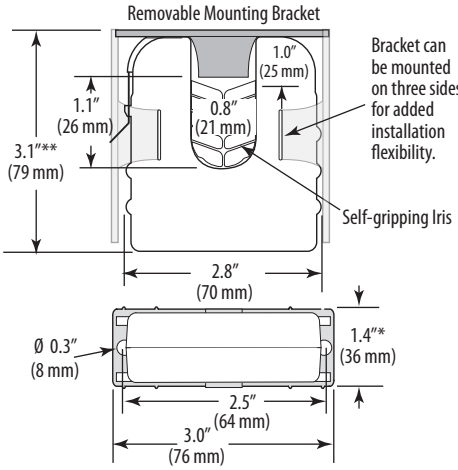
Monitoring Fan /Pump Motors for Positive Proof of Flow



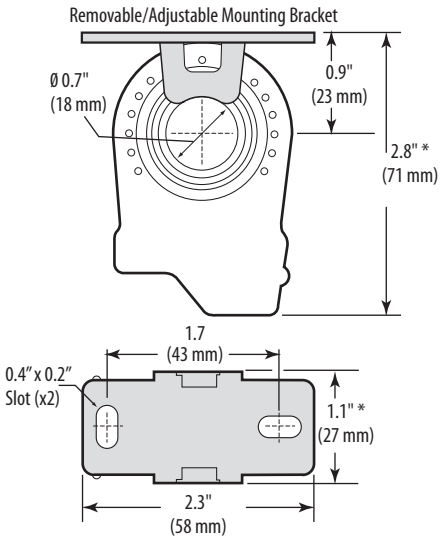
H708/701



H908



H808



* *Terminal block may extend up to 1/8" over the height dimensions shown.*

ORDERING INFORMATION

MODEL	AMPERAGE RANGE @ 50/60 HZ ONLY	STATUS OUTPUT (MAX.)	MIN. TRIP POINT	HOUSING	STATUS LED	UL	CE
H308	0.75 to 50 A	N.O. 1.0 A @ 30 Vac/dc	0.75 A or less	Split-Core	●	●[2]	●
H608	0.5 to 175 A		0.5 A or less	Split-Core	●	●[1]	●
H701	1 to 135 A		1.0 A or less	Solid-Core		●	
H708	1 to 135 A		1.0 A or less	Solid-Core	●	●	
H808	0.75 to 50 A		0.75 A or less	Solid-Core	●	●	●
H908	2.5 to 135 A		2.5 A or less	Split-Core	●	●	●

1. Listed for use on 75 °C insulated conductors.
2. Product provides functional insulation only.

ACCESSORIES

DIN Rail Clip Set (AH01 for H6xx, H8xx, H9xx;
AH27 for H3xx) DIN Rail (AV01) and DIN Stop Clip (AV02)

AH27

AH01

AV01

AV02

HX00 SERIES

On/Off Status Current Switches

CURRENT SENSING THE ULTIMATE PROOF OF FLOW

Maximize Reliability Minimize Installed Cost

Reliable

More reliable for status than relays across auxiliary contacts

Installation flexibility

Removable mounting bracket provides installation flexibility

Ideal for direct-drive units

Ideal for direct-drive units, unit vents, fan coil units, exhaust fans, and other fixed loads

Flexibility

Bracket on H900 can be installed in three different configurations

Low setpoint

Minimum trip point as low as 0.5 A (H608)…avoids the need for multiple wraps of the conductor through the sensor even on loads as small as 1/5 HP

Quick installation

Split-core H300, H600 and H900 for fast retrofit installation

Hawkeye x00 on/off current switches provide a cost-effective solution for monitoring status on unit vents, exhaust fans, recirculation pumps, and other fixed loads where belt loss is not a concern.

Veris has applied new technology to the H300, H600, and H800 models to achieve impressive improvement in turn-on levels. The Hawkeye H300 and H600 have the lowest turn-on current in the industry at a mere 0.15 A!

APPLICATIONS

- Electrical load status
- Direct-drive units, exhaust fans, process motors, and other fixed loads
- Lighting run times and status
- VFD output On/Off status
- Direct-Drive units, unit vents, fan coil units, exhaust fans, and other fixed loads

SPECIFICATIONS

Sensor Power	N.O models: Induced from monitored current; H800NC: 5 to 30 Vdc, permanently connected
Insulation Class	600 Vac RMS (UL), 300 Vac RMS (CE*)
Frequency Range	50/60 Hz, On/Off status for Variable Frequency Drive (VFD) outputs at 12 to 115 Hz (a)
Temperature Range: H800NC, H300, H900 H600 H800, H800HV	 -15 to 60 °C (5 to 140 °F) -15 to 40 °C (5 to 104 °F) (to 200 A); -15 to 60 °C (5 to 140 °F) (to 150 A) -40 to 50 °C (-40 to 122 °F) (to 200 A); -40 to 75 °C (-40 to 167 °F) (to 100 A, and 0.25 A status output)
Humidity Range	10 to 90% RH non-condensing
Off State Leakage (H800NC Only)	34 µA @ 5 Vdc, 200 µA @ 30 Vdc
On State Voltage Drop (H800NC Only)	1.9 Vdc (max.) @ 0.1 A
Terminal Block Wire Size H600, H800, H900 H300	 24 to 14 AWG (0.2 to 2.1 mm^2); 22 to 16 AWG (0.3 to 1.3 mm^2)
Terminal Block Torque H600, H800, H900 H300	 3.5 to 4.4 in-lbs (0.4 to 0.5 N-m); 7 in-lbs (0.8 N-m)
WARRANTY	
Limited Warranty	5 years
AGENCY APPROVALS	
Agency approvals	UL 508 open device listing; CE: EN61010-1, CAT III, Pollution Degree 2, basic insulation

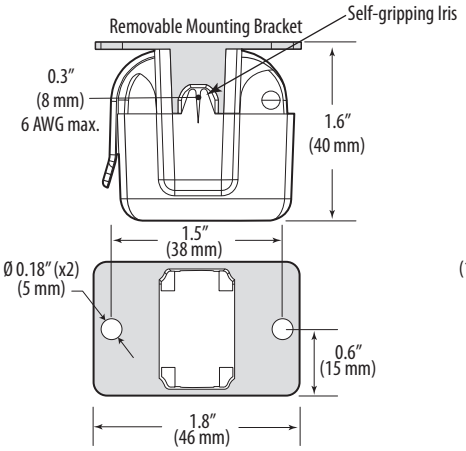
CE c UL us LISTED E150462

*The CE mark indicates RoHS2 compliance. Please refer to the CE Declaration of Conformity for additional details.

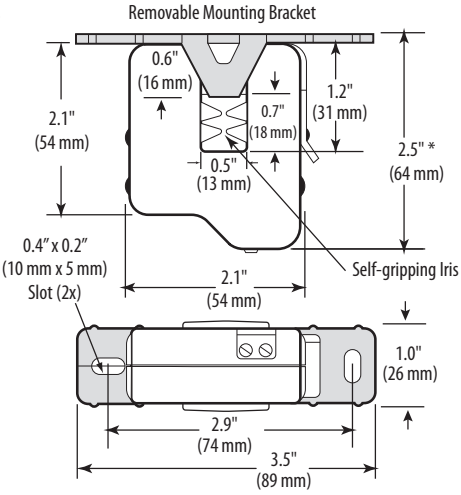
Note: Do not use the LED status indicators as evidence of applied voltage.

(a) VFD systems generate fields that can disrupt electrical devices. Ensure that these fields are minimized and are not affecting the sensor.

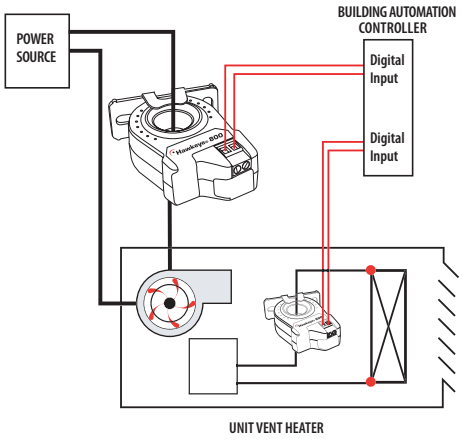
H300
Dimensional Drawing



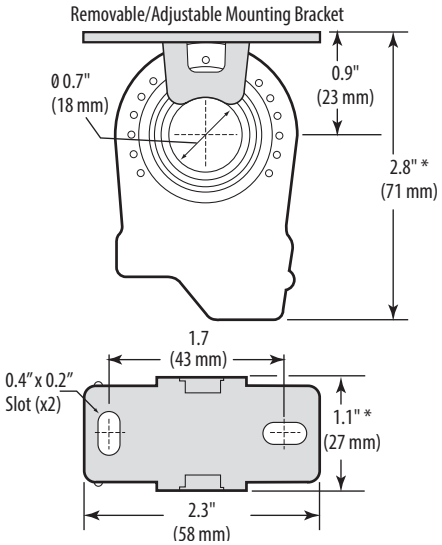
H600
Dimensional Drawing



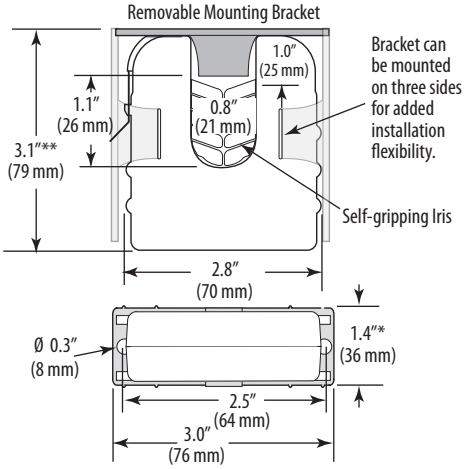
UNIT VENT HEATER CONTROL
Wiring Diagram



H800, H800HV, H800NC
Dimensional Drawing



H900
Dimensional Drawing



* Terminal block may extend up to 1/8″ over the height dimensions shown.
** Slide switch may extend up to 1/4″ over the height dimensions shown.

ORDERING INFORMATION

MODEL	AMPERAGE RANGE @ 50/60 HZ ONLY	STATUS OUTPUT (MAX.)	TRIP POINT	HOUSING	UL	CE	LEAD FREE
H300	0.15 to 60 A	N.O. 1.0 A @ 30 Vac/dc	0.15 A or less	Split-core	•[2]	•	
H600	0.15 to 200 A	N.O. 1.0 A @ 30 Vac/dc	0.15 A or less	Split-core	•[1]	•	
H800	0.25 to 200 A	N.O. 1.0 A @ 30 Vac/dc	0.25 A or less	Solid-core	•[1]	•	
H800NC	0.5 to 200 A	N.C. 0.1 A @ 30 Vdc	0.5 A or less	Solid-core	•[1]		•
H800HV	0.75 to 200 A	N.O. 0.5 A @ 250 Vac/dc	0.75 A or less	Solid-core	•[3]		
H900	1.5 to 200 A	N.O. 1.0 A @ 30 Vac/dc	1.5 A or less	Split-core	•	•	

1. Listed for use on 75°C insulated conductors.
2. Product provides functional insulation only.
3. Listed for use on 90°C insulated conductors.

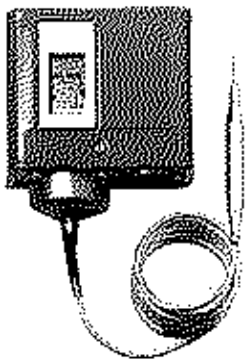
TC-5242 Temperature Controls for Refrigeration and Heating

DESCRIPTION

The TC-5242 low limit thermostat control provide dependability and quality at attractive prices. All TC-5242 controls have a single calibrated scale which shows directly both cut-in and cutout settings. Adjustments can be made readily without removing the cover.

APPLICATION

The TC-5242 single-pole controls are supplied with adjustable 15 to 55°F (-9 to 13°C) temperature range and include a separate reverse-acting auxiliary contact. All Series TC-5242 controls are designed for use only as operating controls. Where an operating control failure would result in personal injury and/or loss of property, it is the responsibility of the installer to add devices (safety, limit controls) or systems (alarm, supervisory systems) that protect against, or warn of, control failure.



FEATURES

- Long life contact structure with high contact force right up to break -- no bounce on make.
- Specified range.
- Auxiliary contact can be used to actuate an alarm circuit when the main contact opens.
- Heavy gauge “low profile” stainless steel element cup to protect against mechanical damage.

Schneider Electric

SPECIFICATIONS

Type	Low limit, single pole thermostat
Adjusting	Screwdriver slot, adjusting knob on differential or range screw when required.
Contact Action	Open on rise, close on rise, SPDT, as required.
Electrical Contacts	Two single pole circuit. Main circuit opens on temperature fall and simultaneously the auxiliary or alarm contacts close.
Contact Unit	Snap-acting high contact force right up to contact break point, no bounce, Beryllium copper conductor leaves with Silver-Cadmium Oxide contacts.
Contact Ratings	Main circuit contacts 16.0 Amps @ 120 vac, 600 V Max. Auxiliary circuit contacts 6.0 Amps @ 120 vac, 600 V Max.
Temperature Range	Adjustable range of 15° F to 55° F (-9° C to 13° C).Low limit stop factory set and sealed at 35° F (2° C).
Max Overrun Temp on Bulb	400° F (204° C).
Finish	Gray baked enamel.
Case Material	0.062" (1.6 mm) cold rolled steel.
Cover Material	0.028" (0.7mm) cold rolled steel.
Element	20 Feet of 1/8 O.D. Tubing responds to lowest temperature along any one foot portion.
Differential	Lockout type, requires manual reset after cutout.
Mounting	May be mounted in any position, two mounting holes provided in back of the case (mounting bracket included).
Shipping Weight	2.5 lb (1.1 kg) with knob
Dimensions	4" L x 3-1/4" H x 2" D (1016 mm L x 826 mm H x 508 mm D)

Notice: This product contains toluene, safely sealed inside of bulb. Contact your local waste management authority for instructions regarding recycling and the proper disposal of an old control containing toulene in a sealed tube.

SmartX™ Living Space Resistive Temperature Sensor
SXWSATXXXRXX

Product Description

SmartX sensors are a family of living space sensors for use with SmartX IP controllers. SmartX sensors are available in communicating and non-communicating versions. Communicating versions are powered and connect to the SmartX IP controller using the RJ-45 Sensor Bus. The SXWSATXXXRXX non-communicating version uses a resistive two-wire connection to connect to an I/O port of the SmartX IP controller.

The SXWSATXXXRXX with its reliable 10K Type 3 thermistor and the same look and feel as communicating SmartX sensors, provides a low cost option for measuring temperature in a living space application.

Features

- Contemporary, sleek housing, same form factor as SmartX communicating sensors
- Low cost conformance part
- 10K Type 3 thermistor
- Two-wire resistive device

Applicable Documentation

Title	Description
SmartX Living Space Sensor Base	Installation instructions for all base variants
SmartX Living Space Sensor Blank Cover	Installation instructions for blank cover without occupancy sensor
SmartX Living Space Sensor Button and Occupancy Covers	Installation instructions for 3-button covers with and without occupancy sensors and blank cover with occupancy sensor
SmartX Living Space Sensor Touchscreen Cover	Installation instructions for touchscreen models with and without occupancy sensors
SmartX Living Space LCD Temperature Sensor	LCD temperature sensor base and cover installation instructions

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Asia: +65 6484 7877
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Available Products

SmartX Combination Base/Cover Sensors

Model Number	Description	Temp	RH	CO_2	Cover	SmartX System Bus (Communicating)	Resistive Only (Non-communicating)
SXWSATXXXRXX*	Sensor, Temperature, 10K T3, Non-Communicating, Cover Plate	X			Included		X
SXWSATXXXSLX	Sensor, Temperature, LCD, Setpoint, Pushbutton Override, Cover Plate	X			Included	X	

SmartX Sensor Bases

Model Number	Description	Temp	RH	CO_2	Cover	SmartX System Bus (Communicating)
SXWSBTXXXSXX	Sensor Base, Temperature	X			Not Included	X
SXWSBTHXXSXX	Sensor Base, Temperature, Humidity	X	X		Not Included	X
SXWSBTXCXSXX	Sensor Base, Temperature, CO_2	X		X	Not Included	X
SXWSBTHCXSXX	Sensor Base, Temperature, Humidity, CO_2	X	X	X	Not Included	X

SmartX Covers**

Model Number	Description	61 mm (2.4") Color Touchscreen	Override	Setpoint	Occupancy Sensor (PIR)
SXWSCDXSELXX	Cover Plate, User Interface, Basic	X	X	X	
SXWSC3XSELXX	Cover Plate, Pushbutton Override, Setpoint		X	X	
SXWSCBXSELXX	Cover Plate, Blank Cover				
SXWSCDPSELXX	Cover Plate, User Interface, Basic, Occupancy	X	X	X	X
SXWSC3PSELXX	Cover Plate, Pushbutton Override, Setpoint, Occupancy		X	X	X
SXWSCBPSELXX	Cover Plate, Blank Cover, Occupancy				X

* Covered by these installation instructions.
** SmartX covers will not work with combination base/cover sensors.

Specifications

Temperature Sensor	
Type	10K Type 3 thermistor
Accuracy	±0.2 °C (±0.36 °F) typical
Operating Environment	
Operating temperature	0 to 50 °C (32 to 122 °F)
Operating humidity range	0 to 95% RH, non-condensing
Housing material	High impact ABS plastic Flammability rating UL 94 V-0
Mounting location	Not suitable for wet locations. For indoor use only.
Wiring	
Two screw terminals	18-22 AWG, two-wire thermistor
Regulatory Information	
Agency approvals	UL 916, European conformance CE: EN61000-6-3 EN61000 Series - industrial immunity standard FCC Part 15 Class B, REACH, RoHS, Green Premium, RCM (Australia), ICES-003 (Canada), EAC (Russia)

Thermistor Table

°C	°F	Resistance (Ω)
0	32	29,575
5	41	23,504
10	50	18,809
15	59	15,146
20	68	12,271
25	77	10,000
30	86	8,195
35	95	6,752
40	104	5,592
45	113	4,655
50	122	3,893

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Precautions

⚠ ⚠ DANGER

HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH

- Follow safe electrical work practices. See NFPA 70E in the USA, CSA Z462 in Canada, or applicable local codes.
- Read and understand the instructions before installing the product. Follow the instructions during installation.
- Installation, wiring, testing or service must be performed only by qualified persons in accordance with all applicable codes and regulations.
- Do not use the product for life or safety applications.
- Do not install the product in hazardous or classified locations.
- Do not exceed the product's ratings or maximum limits.
- Turn off ALL power supplying equipment before working on or inside the equipment.
- Use a properly rated voltage sensing device to confirm that all power is off.
- Do not depend on the product for voltage indication.
- Remove all wire scraps and tools, replace all doors, covers and protective devices before powering the equipment.

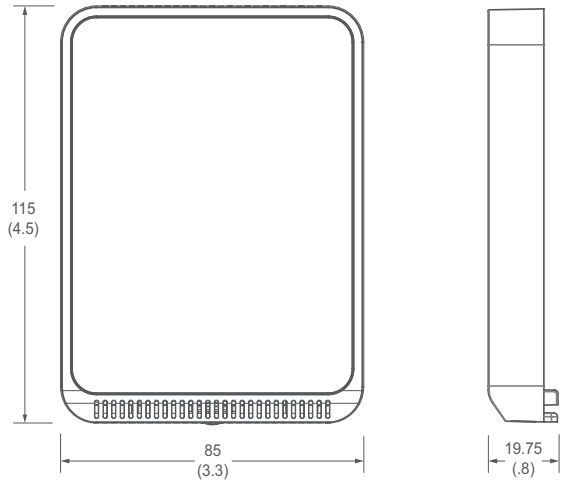
Failure to follow these instructions will result in death or serious injury.

A qualified person is one who has skills and knowledge related to the construction and operation of this electrical equipment and installations, and has received safety training to recognize and avoid the hazards involved. NEC Article 100

If this product is used in a manner not specified by the manufacturer, the protection provided by the product may be impaired. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material.

Dimensions mm (in.)

SmartX Resistive Temperature Sensor Base with Cover Installed

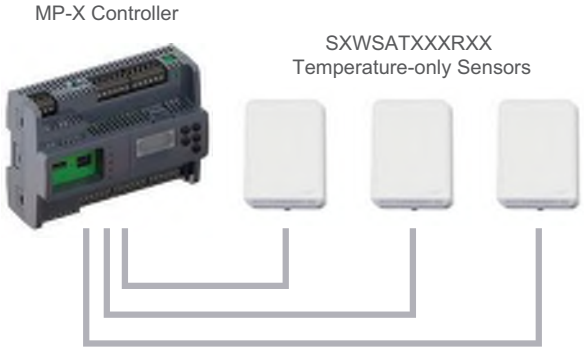


Functions

The SXWSATXXXRXX measures temperature in living space applications. It provides a resistive output to an I/O port on a SmartX or Continuum controller.

System Architecture

MP-X Controller and Non-Communicating Sensors



Each sensor uses an I/O port on the controller.
Maximum number of inputs varies by controller type.

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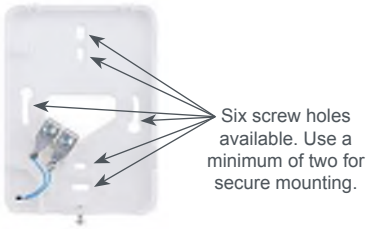
Installation

1. Position the sensor vertically on the wall 1.35 m (4.5 ft.) above the floor with the “UP” arrow facing upward. Locate away from windows, vents and other sources of draft. If possible, do not mount on an external wall, as this may cause inaccurate temperature readings.

2. Pull 18 or 22 AWG two-conductor cable(s) through the hole in the backplate.

3. Mount the backplate onto the wall using the screws provided.



4. Connect the wires to the termistor terminals. Do not over-tighten the screws.

5. With sensor base fully installed, align top of cover to mounting tabs on top of sensor base. Swing cover downward until it latches at the bottom.

6. Install locking screw to secure cover in closed position.

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China RoHS Compliance Information
Environment-Friendly Use Period (EFUP) Table

部件名称	有害物质 - Hazardous Substances					
Part Name	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 (Cr (VI))	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
电子件 Electronic	X	O	O	O	O	O

本表格依据SJ/T11364的规定编制。
O: 表示该有害物质在该部件所有均质材料中的含量均在GB/T 26572规定的限量要求以下。
X: 表示该有害物质至少在该部件的某一均质材料中的含量超出GB/T 26572规定的限量要求。
（企业可在此处，根据实际情况对上表中打 "X" 的技术原因进行进一步说明。）

This table is made according to SJ/T 11364.
O: indicates that the concentration of hazardous substance in all of the homogeneous materials for this part is below the limit as stipulated in GB/T 26572.
X: indicates that concentration of hazardous substance in at least one of the homogeneous materials used for this part is above the limit as stipulated in GB/T 26572

Z000057-0B

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Life Is On Schneider Electric

March 2018
Z207554-0C nk

EP Series

Differential Pressure/Air Velocity Transducer

Product Description

The EP transducer can measure either air pressure or velocity with the flip of a switch. The EP is available in three installation configurations: duct, panel or universal. Duct and panel models have two pressure and velocity options: 0-1” WC / 0-3,000 ft/min or 1-10” WC / 3,000-6,000 ft/min with four field-selectable sub-ranges. The universal model comes in one pressure/velocity range: 0-10” WC / 0-7,000 ft/min with seven field-selectable sub-ranges for pressure and eight for velocity. All variants are available with and without display. The EP has an IP65/NEMA 4 environmental rating and a 5-year limited warranty.

Features

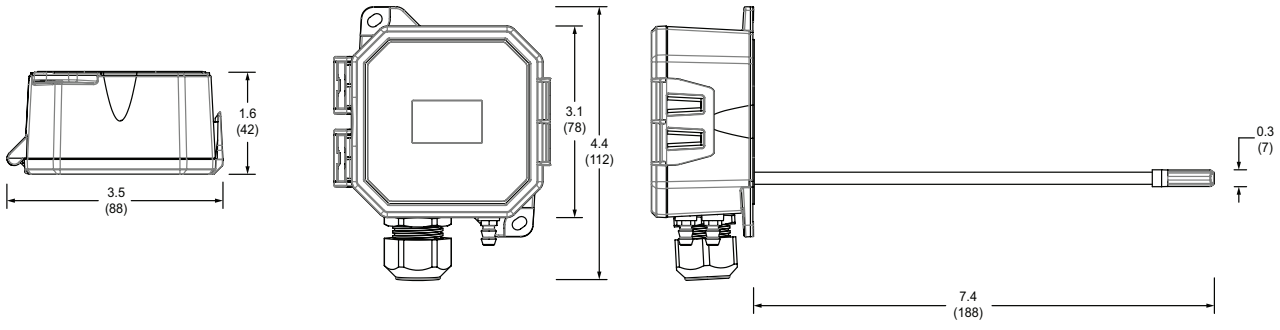
- High reliability sensor technology for long-term, maintenance-free operation
- Seven pressure and eight velocity sub-ranges with three selectable outputs for easy on-the-job setup
- IP65/NEMA 4 housing allows mounting in wash-down locations
- Circuit protection avoids damage due to incorrect input wiring

Available Products

Enclosure	Range	Local Display
EP □ D = Duct P = Panel	301 = Pressure: 0 to 1 in. WC 0 to 250 Pa Velocity: 0 to 3000 ft/min 0 to 15 m/s 302 = Pressure: 0 to 10 in. WC 0 to 2500 Pa Velocity: 0 to 6000 ft/min 0 to 30 m/s	□ Blank = No Display LCD = LCD Display

Enclosure	Range	Local Display
EP U U = Universal	305 = Pressure: 0 to 10 in. WC 0 to 2500 Pa Velocity: 0 to 7000 ft/min 0 to 35 m/s	□ Blank = No Display LCD = LCD Display

Dimensions in. (mm)



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Life Is On Schneider Electric

December 2017
F-28091-1 nk

Specifications

Media Compatibility	Dry or inert gas
Input Power	Three-wire Volt mode: 24 Vac or 12-30 Vdc*, Two-wire mA mode: 12-30 Vdc*
Output Power	Field-selectable: 2-wire, loop-powered 4-20 mA** (DC only, clipped and capped), 24 Vac/dc or 3-wire 0-5V/0-10V***
301 Pressure Range	Pressure mode: Unidirectional: 0.1/0.25/0.5/1.0 in. WC FS, switch selectable Bidirectional: ±0.1/±0.25/±0.5/±1.0 in. WC FS, switch selectable Unidirectional: 25 Pa/50 Pa/100 Pa/250 Pa, FS, switch selectable Bidirectional: ±25 Pa/±50 Pa/±100 Pa/±250 Pa, FS, switch selectable Velocity mode: 500/1,000/2,000/3,000 ft/min, 2.5/5/10/15 m/s
302 Pressure Range	Pressure mode: Unidirectional: 1.0/2.5/5.0/10 in. WC FS, switch selectable Bidirectional: ±1.0/±2.5/±5.0/±10 in. WC FS, switch selectable Unidirectional: 0.250 kPa/0.500 kPa/1.000 kPa/2.500 kPa, FS, switch selectable Bidirectional: ±0.250 kPa/±0.500kPa/±1.000 kPa/±2.500 kPa, FS, switch selectable Velocity mode: 3,000/4,000/5,000/6,000 ft/min, 15/20/25/30 m/s
305 Pressure Range	Pressure mode: Unidirectional: 0.1/0.25/0.5/1.0/2.5/5/10 in. WC FS, switch selectable Bidirectional: ±0.1/0.25/0.5/1.0/2.5/5/10 in. WC FS, switch selectable Unidirectional: 25Pa/50Pa/100Pa/250Pa/0.5kPa/1kPa/2.5kPa FS, switch selectable Bidirectional: ±25Pa/50Pa/100Pa/250Pa/0.5kPa/1kPa/2.5kPa FS, switch selectable Velocity mode: 500/1000/2000/3000/4000/5000/6000/7000 ft/min, 2.5/5/10/15/20/25/30/35 m/s
Response Time	Standard: T95 in 20 sec, Fast: T95 in 2 sec, DIP switch selectable
Mode	Unidirectional or bidirectional, DIP switch selectable
Display (Option)	Pressure mode: Signed 3-1/2 digit LCD, indicates pressure, overrange indicator Velocity mode: Signed 4-1/2 digit LCD, indicates velocity, overrange indicator
Proof Pressure	3 psid (20.6 kPa)
Burst Pressure	5 psid (34.5 kPa)
Pressure Mode Accuracy	±1% FS (combined linearity and hysteresis)
Velocity Mode Accuracy	±90 ft/min (±0.45 m/s) plus 5% of measured value****
Temperature Effect	1” (250 Pa) models: 0.05%/°C; 10” (2.5 kPa) models: 0.01%/°C (Relative to 25 °C) 0 to 50 °C (32 to 122 °F)
Zero Drift (1 year)	1” (250 Pa) models: 2.0% max.; 10” (2.5 kPa) models: 0.5% max.
Zero Adjust	Pushbutton auto-zero and digital input (2-position terminal block)
Operating Environment	0 to 60 °C (32 to 140 °F)
Altitude of Operation	0 to 3000 m
Pollution Degree	2
Humidity Range	100% RH, non-condensing
Mounting Location	For indoor use only.
Fittings	Brass barb; 0.24” (6.1 mm) o.d.
Limited Warranty	5 years
Environmental Rating	IP65, NEMA 4
Flammability Rating	UL 94 5VA fire retardant ABS, plenum rated

EMC Conformance: EN 61000-6-3 and A1 Class B, EN 61000-6-1.
* Class 2/II power source.
** Minimum input voltage for 4 to 20 mA operation: 250 Ω loop = 12 Vdc; 500 Ω loop = 19 Vdc.
*** Minimum load resistance for Volt operation: 5 kΩ.
**** For measured values between 200 and 7000 ft/min (1 and 35 m/s).

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Life Is On Schneider Electric

December 2017
F-28091-1 nk

5-year warranty

Technical data

Functional data	Valve Size	0.5" [15]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	0...250°F [-18...120°C]
	Body Pressure Rating	600 psi
	Close-off pressure Δps	200 psi
	Flow characteristic	equal percentage
	Servicing	maintenance-free
	Flow Pattern	2-way
	Leakage rate	0% for A – AB
	Controllable flow range	75°
	Cv	7.4
	Body pressure rating note	600 psi
	Cv Flow Rating	A-port: as stated in chart B-port: 70% of A – AB Cv
Materials	Valve body	Nickel-plated brass body
	Stem seal	EPDM (lubricated)
	Seat	PTFE
	Pipe connection	NPT female ends
	O-ring	EPDM (lubricated)
	Ball	stainless steel
Suitable actuators	Non-Spring	TR LRB(X) NR

Safety notes

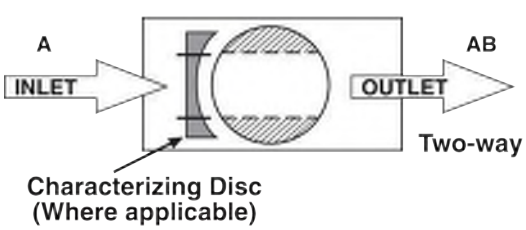
- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov

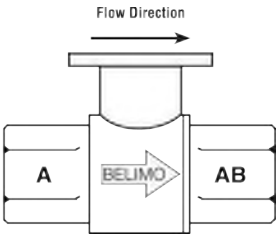
Product features

Application

This valve is typically used in air handling units on heating or cooling coils, and fan coil unit heating or cooling coils. Some other common applications include Unit Ventilators, VAV box re-heat coils and bypass loops. This valve is suitable for use in a hydronic system with variable flow.

Flow/Mounting details

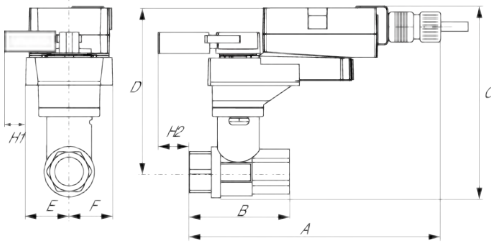




Dimensions

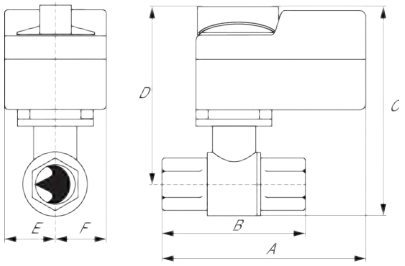
Dimensional drawings

LRB, LRX



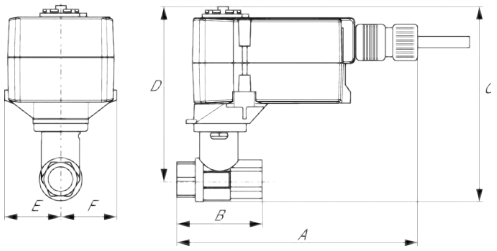
A	B	C	D	E	F	H1	H2
9.4" [239]	2.4" [60]	5.6" [141]	5.0" [127]	1.3" [33]	1.3" [33]	1.2" [30]	1.1" [28]

TR



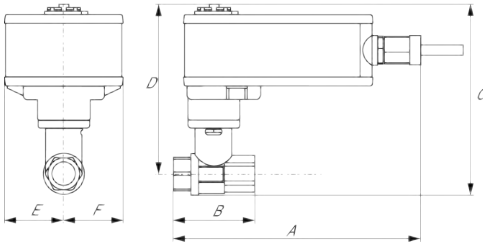
A	B	C	D	E	F
3.7" [95]	2.4" [60]	5.2" [132]	4.6" [117]	1.3" [33]	1.3" [33]

TFRB, TFRX



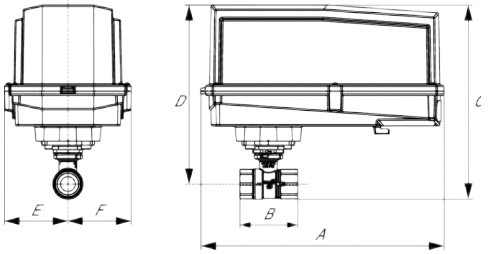
A	B	C	D	E	F
6.6" [167]	2.4" [60]	5.5" [139]	4.7" [120]	1.5" [39]	1.5" [39]

LF



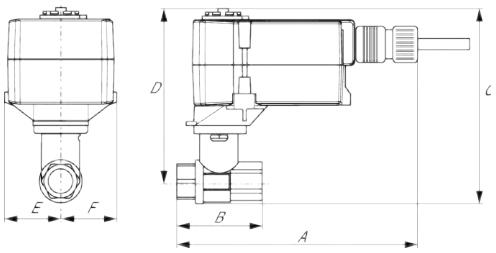
A	B	C	D	E	F
7.9" [200]	2.4" [60]	6.1" [154]	5.5" [140]	1.8" [46]	1.8" [46]

ARB N4, ARX N4, NRB N4, NRX N4



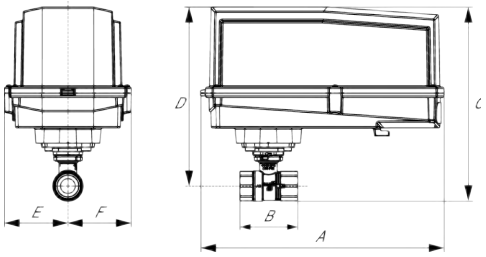
A	B	C	D	E	F
11.4" [289]	2.4" [60]	7.7" [196]	7.0" [179]	3.1" [80]	3.1" [80]

TFRB, TFRX



A	B	C	D	E	F
6.6" [167]	2.4" [60]	5.5" [139]	4.7" [120]	1.5" [39]	1.5" [39]

ARB N4, ARX N4, NRB N4, NRX N4



A	B	C	D	E	F
11.4" [289]	2.4" [60]	7.7" [196]	7.0" [179]	3.1" [80]	3.1" [80]

BELIMO

Modulating, Spring Return, AC 24 V for DC 2...10 V or 4...20 mA Control Signal

Technical data sheet TFRX24-SR

5-year warranty

Technical data

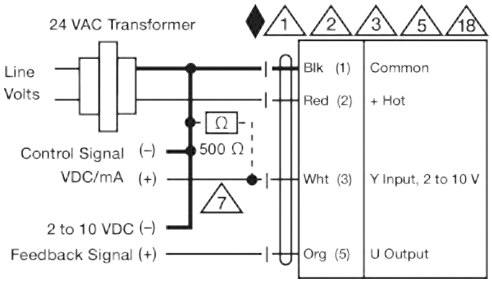
Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	2 W
	Power consumption in rest position	1 W
	Transformer sizing	4 VA (class 2 power source)
	Electrical Connection	18 GA appliance or plenum cables, 3 ft [1 m], 10 ft [3 m] or 16ft [5 m], with 1/2" conduit connector
	Overload Protection	electronic throughout 0...95° rotation
Functional data	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for 2...10 V (0.1 mA), 500 Ω for 4...20 mA
	Position feedback U	2...10 V
	Position feedback U note	Max. 0.5 mA
	Direction of motion motor	selectable with switch 0/1
	Direction of motion fail-safe	reversible with cw/ccw mounting
	Angle of rotation	Max. 95°, adjustable with mechanical stop
	Angle of rotation note	adjustable with mechanical stop
	Running Time (Motor)	95 s
	Running time fail-safe	<25 s tamb = 68°F [20°C]
	Noise level, motor	35 dB(A)
	Noise level, fail-safe	62 dB(A)
	Position indication	Mechanical
Safety data	Degree of protection IEC/EN	IP42
	Degree of protection NEMA/UL	NEMA 2 UL Enclosure Type 2
	Agency Listing	cULus acc. to UL60730-1A/-2-14, CAN/CSA E60730-1:02, CE acc. to 2014/30/EU and 2014/35/EU; Listed to UL 2043 - suitable for use in air plenums per Section 300.22(c) of the NEC and Section 602.2 of the IMC
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	1.8 lb [0.80 kg]
Materials	Housing material	UL94-5VA

Electrical installation

INSTALLATION NOTES

1 Provide overload protection and disconnect as required.
2 Actuators may be connected in parallel. Power consumption and input impedance must be observed.
3 Actuators may also be powered by 24 VDC.
5 Only connect common to negative (-) leg of control circuits.
7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.
18 Actuators with plenum cable do not have numbers; use color codes instead.
◆ Meets cULus requirements without the need of an electrical ground connection.

Warning! Live Electrical Components!
During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.



2...10 V / 4...20 mA Control

BELIMO

Chrome Plated Brass Ball and Nickel Plated Brass Stem

Technical data sheet B219B

5-year warranty

Technical data

Functional data	Valve Size	0.75" [20]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	0...250°F [-18...120°C]
	Body Pressure Rating	600 psi
	Close-off pressure Δps	200 psi
	Flow characteristic	equal percentage
	Servicing	maintenance-free
	Flow Pattern	2-way
	Leakage rate	0% for A – AB
	Controllable flow range	75°
	Cv	10
	Body pressure rating note	600 psi
	Cv Flow Rating	A-port: as stated in chart B-port: 70% of A – AB Cv
Materials	Valve body	Nickel-plated brass body
	Stem seal	EPDM (lubricated)
	Seat	PTFE
	Pipe connection	NPT female ends
	O-ring	EPDM (lubricated)
	Ball	chrome plated brass
Suitable actuators	Non-Spring	TR LRB(X)

Safety notes

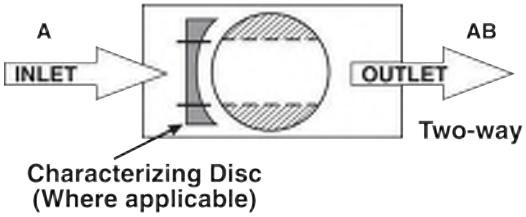
- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov

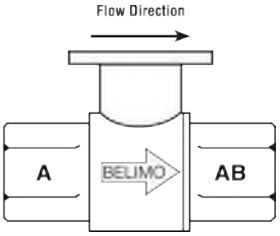
Product features

Application

This valve is typically used in air handling units on heating or cooling coils, and fan coil unit heating or cooling coils. Some other common applications include Unit Ventilators, VAV box re-heat coils and bypass loops. This valve is suitable for use in a hydronic system with variable flow.

Flow/Mounting details

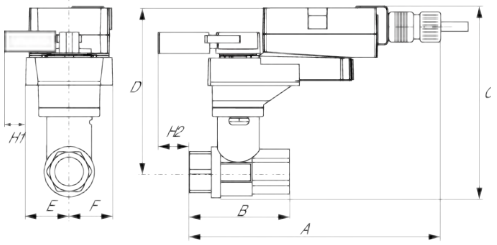




Dimensions

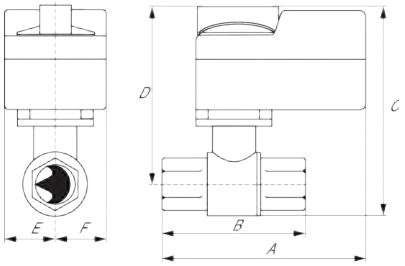
Dimensional drawings

LRB, LRX



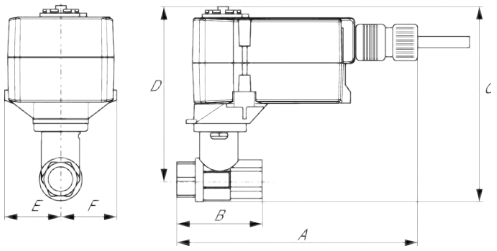
A	B	C	D	E	F	H1	H2
9.4" [239]	2.7" [69]	5.8" [147]	5.1" [129]	1.3" [33]	1.3" [33]	1.2" [30]	1" [25]

TR



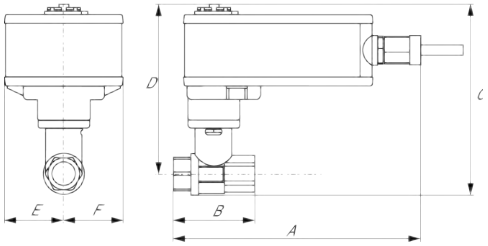
A	B	C	D	E	F
4.0" [102]	2.7" [69]	5.4" [137]	5.1" [129]	1.3" [33]	1.3" [33]

TFRB, TFRX



A	B	C	D	E	F
7.0" [178]	2.7" [69]	5.5" [139]	4.8" [122]	1.5" [39]	1.5" [39]

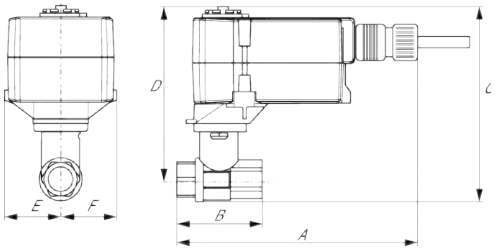
LF



A	B	C	D	E	F
8.6" [218]	2.7" [69]	6.3" [159]	5.6" [142]	1.8" [46]	1.8" [46]

A	B	C	D	E	F
8.6" [218]	2.7" [69]	6.3" [159]	5.6" [142]	1.8" [46]	1.8" [46]

TFRB, TFRX



A	B	C	D	E	F
7.0" [178]	2.7" [69]	5.5" [139]	4.8" [122]	1.5" [39]	1.5" [39]

BELIMO

Modulating, Non-Spring Return, 24 V, for DC 2...10 V or 4...20 mA

Technical data sheet TR24-SR US

5-year warranty

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	0.5 W
	Transformer sizing	1 VA (class 2 power source)
	Electrical Connection	18 GA plenum cable, 3 ft [1 m]
	Overload Protection	electronic throughout full rotation
Functional data	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for 2...10 V (0.1 mA), 500 Ω for 4...20 mA
	Direction of motion motor	selectable with switch
	Manual override	push down handle
	Angle of rotation	90°
	Running Time (Motor)	90 s / 90°
	Noise level, motor	35 dB(A)
	Position indication	Mechanically, pluggable
Safety data	Degree of protection IEC/EN	IP40
	Degree of protection NEMA/UL	NEMA 1 UL Enclosure Type 1
	Agency Listing	cULus acc. to UL60730-1A/-2-14, CAN/CSA E60730-1:02, CE acc. to 2014/30/EU and 2014/35/EU; Listed to UL 2043 - suitable for use in air plenums per Section 300.22(c) of the NEC and Section 602.2 of the IMC
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	0.70 lb [0.32 kg]

Safety notes

- Cable for ZIP-RS232 US and ZIP-USB-MP US to Belimo gateways.
- Battery Back Up System for SY(7~10)-110
- 120 to 24 VAC, 40 VA transformer.
- Cable for ZTH US to actuators w/o diagnostics socket.
- 50% voltage divider kit (resistors with wires).
- PC Tool computer programming interface, serial port.

Electrical installation

INSTALLATION NOTES

1 Provide overload protection and disconnect as required.

3 Actuators may also be powered by 24 VDC.

5 Only connect common to negative (-) leg of control circuits.

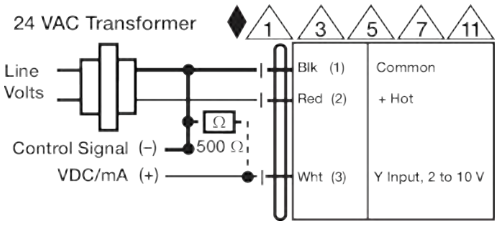
7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.

11 Actuators may be connected in parallel if not mechanically linked. Power consumption and input impedance must be observed.

Meets cULus requirements without the need of an electrical ground connection.

Warning! Live Electrical Components!

During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.



2...10 V / 4...20 mA Control

BELIMO

Stainless Steel Ball and Stem

Technical data sheet B220

5-year warranty

Technical data

Functional data	Valve Size	0.75" [20]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	0...250°F [-18...120°C]
	Body Pressure Rating	600 psi
	Close-off pressure Δps	200 psi
	Flow characteristic	equal percentage
	Servicing	maintenance-free
	Flow Pattern	2-way
	Leakage rate	0% for A – AB
	Controllable flow range	75°
	Cv	14
	Body pressure rating note	600 psi
	No Characterized Disc	TRUE
	Cv Flow Rating	A-port: as stated in chart B-port: 70% of A – AB Cv
Materials	Valve body	Nickel-plated brass body
	Stem seal	EPDM (lubricated)
	Seat	PTFE
	Pipe connection	NPT female ends
	O-ring	EPDM (lubricated)
	Ball	stainless steel
Suitable actuators	Non-Spring	TR LRB(X) NR

Safety notes

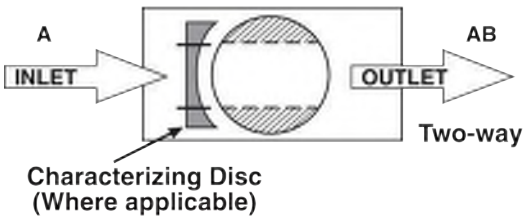
- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov

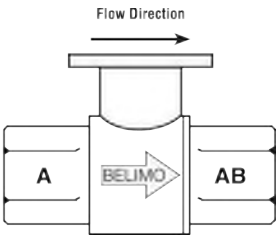
Product features

Application

This valve is typically used in air handling units on heating or cooling coils, and fan coil unit heating or cooling coils. Some other common applications include Unit Ventilators, VAV box re-heat coils and bypass loops. This valve is suitable for use in a hydronic system with variable flow.

Flow/Mounting details

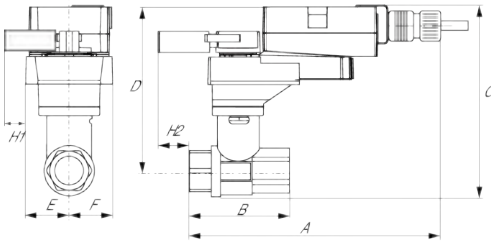




Dimensions

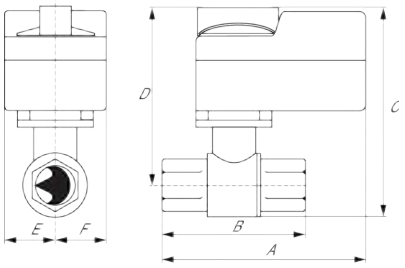
Dimensional drawings

LRB, LRX



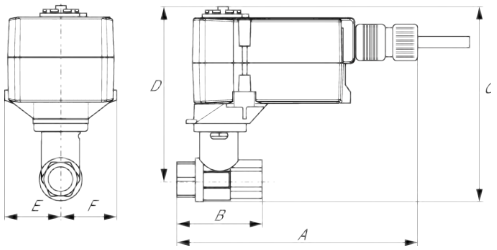
A	B	C	D	E	F	H1	H2
9.4" [239]	2.7" [69]	5.8" [147]	5.1" [129]	1.3" [33]	1.3" [33]	1.2" [30]	1" [25]

TR



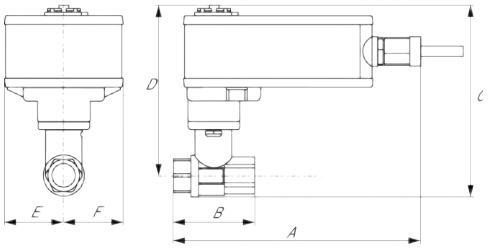
A	B	C	D	E	F
4.0" [102]	2.7" [69]	5.4" [137]	5.1" [129]	1.3" [33]	1.3" [33]

TFRB, TFRX



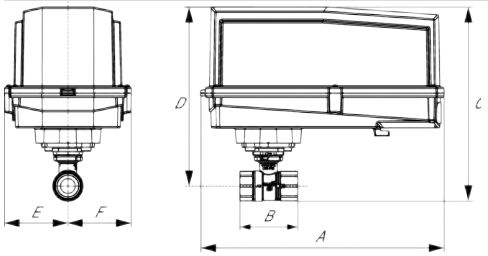
A	B	C	D	E	F
7.0" [178]	2.7" [69]	5.5" [139]	4.8" [122]	1.5" [39]	1.5" [39]

LF



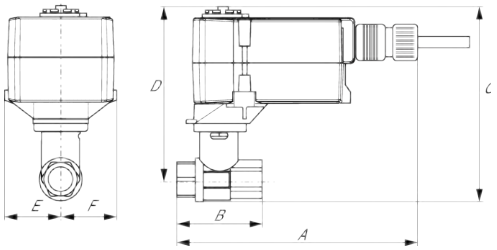
A	B	C	D	E	F
8.6" [218]	2.7" [69]	6.3" [159]	5.6" [142]	1.8" [46]	1.8" [46]

ARB N4, ARX N4, NRB N4, NRX N4



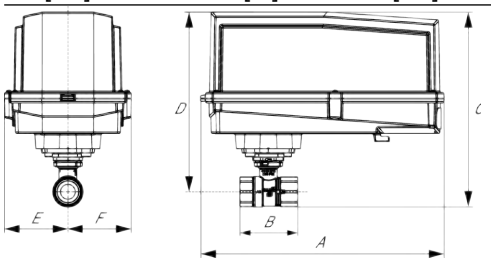
TFRB, TFRX

A	B	C	D	E	F
11.4" [289]	2.7" [69]	7.8" [199]	7.1" [181]	3.1" [80]	3.1" [80]



ARB N4, ARX N4, NRB N4, NRX N4

A	B	C	D	E	F
7.0" [178]	2.7" [69]	5.5" [139]	4.8" [122]	1.5" [39]	1.5" [39]



A	B	C	D	E	F
11.4" [289]	2.7" [69]	7.8" [199]	7.1" [181]	3.1" [80]	3.1" [80]

BELIMO

Modulating, Spring Return, AC 24 V for DC 2...10 V or 4...20 mA Control Signal

Technical data sheet TFRB24-SR

5-year warranty

Technical data

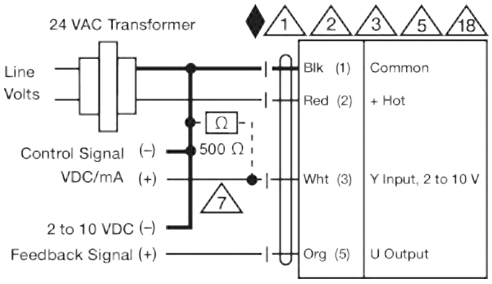
Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	2 W
	Power consumption in rest position	1 W
	Transformer sizing	4 VA (class 2 power source)
	Electrical Connection	18 GA plenum cable, 3 ft [1 m], with 1/2" conduit connector
	Overload Protection	electronic throughout 0...95° rotation
Functional data	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for 2...10 V (0.1 mA), 500 Ω for 4...20 mA
	Position feedback U	2...10 V
	Position feedback U note	Max. 0.5 mA
	Direction of motion motor	selectable with switch 0/1
	Direction of motion fail-safe	reversible with cw/ccw mounting
	Angle of rotation	Max. 95°, 90°
	Angle of rotation note	90°
	Running Time (Motor)	95 s
	Running time fail-safe	<25 s tamb = 68°F [20°C]
	Noise level, motor	35 dB(A)
	Noise level, fail-safe	62 dB(A)
	Position indication	Mechanical
Safety data	Degree of protection IEC/EN	IP42
	Degree of protection NEMA/UL	NEMA 2 UL Enclosure Type 2
	Agency Listing	cULus acc. to UL60730-1A/-2-14, CAN/CSA E60730-1:02, CE acc. to 2014/30/EU and 2014/35/EU; Listed to UL 2043 - suitable for use in air plenums per Section 300.22(c) of the NEC and Section 602.2 of the IMC
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	1.6 lb [0.80 kg]
Materials	Housing material	UL94-5VA

Electrical installation

INSTALLATION NOTES

1 Provide overload protection and disconnect as required.
2 Actuators may be connected in parallel. Power consumption and input impedance must be observed.
3 Actuators may also be powered by 24 VDC.
5 Only connect common to negative (-) leg of control circuits.
7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.
18 Actuators with plenum cable do not have numbers; use color codes instead.
◆ Meets cULus requirements without the need of an electrical ground connection.

Warning! Live Electrical Components!
During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.



2...10 V / 4...20 mA Control

BELIMO

Stainless Steel Ball and Stem

Technical data sheet B221

5-year warranty

Technical data

Functional data	Valve Size	0.75" [20]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	0...250°F [-18...120°C]
	Body Pressure Rating	600 psi
	Close-off pressure Δps	200 psi
	Flow characteristic	equal percentage
	Servicing	maintenance-free
	Flow Pattern	2-way
	Leakage rate	0% for A – AB
	Controllable flow range	75°
	Cv	24
	Body pressure rating note	600 psi
	No Characterized Disc	TRUE
	Cv Flow Rating	A-port: as stated in chart B-port: 70% of A – AB Cv
Materials	Valve body	Nickel-plated brass body
	Stem seal	EPDM (lubricated)
	Seat	PTFE
	Pipe connection	NPT female ends
	O-ring	EPDM (lubricated)
	Ball	stainless steel
Suitable actuators	Non-Spring	LRB(X) NR

Safety notes

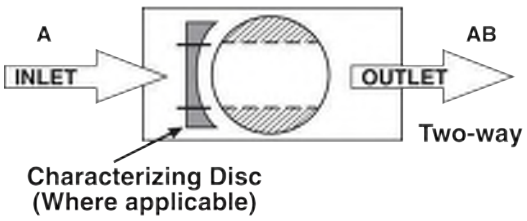
- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov

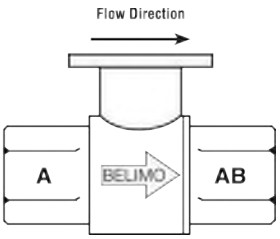
Product features

Application

This valve is typically used in air handling units on heating or cooling coils, and fan coil unit heating or cooling coils. Some other common applications include Unit Ventilators, VAV box re-heat coils and bypass loops. This valve is suitable for use in a hydronic system with variable flow.

Flow/Mounting details

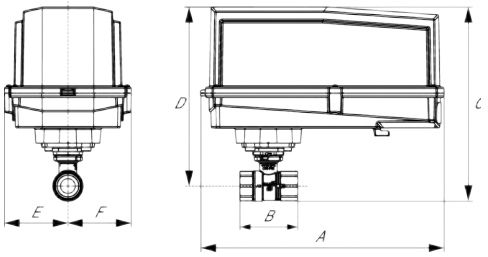




Dimensions

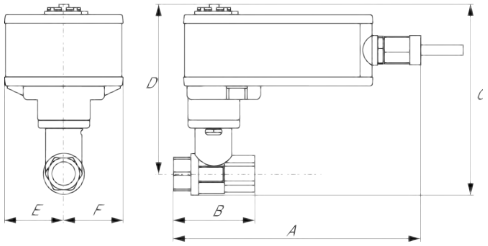
Dimensional drawings

ARB N4, ARX N4, NRB N4, NRX N4



A	B	C	D	E	F
11.4" [289]	2.7" [69]	7.8" [199]	7.1" [181]	3.1" [80]	3.1" [80]

LF



A	B	C	D	E	F
8.6" [218]	2.7" [69]	6.3" [159]	5.6" [142]	1.8" [46]	1.8" [46]

BELIMO

Modulating, Non-Spring Return, 24 V, for DC 2...10 V or 4...20 mA

Technical data sheet LRB24-SR

5-year warranty

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	1.5 W
	Power consumption in rest position	0.4 W
	Transformer sizing	3 VA (class 2 power source)
	Electrical Connection	18 GA plenum cable, 3 ft [1 m], with 1/2" conduit connector
	Overload Protection	electronic thoughout 0...90° rotation
Functional data	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for 2...10 V (0.1 mA), 500 Ω for 4...20 mA
	Position feedback U	2...10 V
	Direction of motion motor	selectable with switch 0/1
	Manual override	external push button
	Angle of rotation	90°
	Angle of rotation note	adjustable with mechanical stop
	Running Time (Motor)	90 s
	Noise level, motor	35 dB(A)
	Position indication	Mechanically, pluggable
Safety data	Degree of protection IEC/EN	IP54
	Degree of protection NEMA/UL	NEMA 2 UL Enclosure Type 2
	Agency Listing	cULus acc. to UL60730-1A/-2-14, CAN/CSA E60730-1:02, CE acc. to 2014/30/EU
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	1.1 lb [0.50 kg]

Safety notes

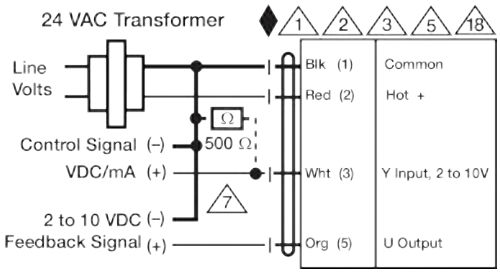
- Weather shield - PC w/ foam seal 16x8-3/8x4" (LxWxD).
- Classic GM to GMB(X) retrofit bracket.
- Battery Back Up System for SY(7~10)-110
- 120 to 24 VAC, 40 VA transformer.
- Cable for ZTH US to actuators w/o diagnostics socket.
- PC Tool computer programming interface, serial port.

Electrical installation

INSTALLATION NOTES

1 Provide overload protection and disconnect as required.
2 Actuators may be connected in parallel. Power consumption and input impedance must be observed.
3 Actuators may also be powered by 24 VDC.
5 Only connect common to negative (-) leg of control circuits.
7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.
18 Actuators with plenum cable do not have numbers; use color codes instead.
◆ Meets cULus requirements without the need of an electrical ground connection.

Warning! Live Electrical Components!
During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.



2...10 V / 4...20 mA Control

BELIMO

Stainless Steel Ball and Stem

Technical data sheet B224

5-year warranty

Technical data

Functional data	Valve Size	1" [25]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	0...250°F [-18...120°C]
	Body Pressure Rating	600 psi
	Close-off pressure Δps	200 psi
	Flow characteristic	equal percentage
	Servicing	maintenance-free
	Flow Pattern	2-way
	Leakage rate	0% for A – AB
	Controllable flow range	75°
	Cv	19
	Body pressure rating note	600 psi
	Cv Flow Rating	A-port: as stated in chart B-port: 70% of A – AB Cv
Materials	Valve body	Nickel-plated brass body
	Stem seal	EPDM (lubricated)
	Seat	PTFE
	Pipe connection	NPT female ends
	O-ring	EPDM (lubricated)
	Ball	stainless steel
Suitable actuators	Non-Spring	LRB(X) NR

Safety notes

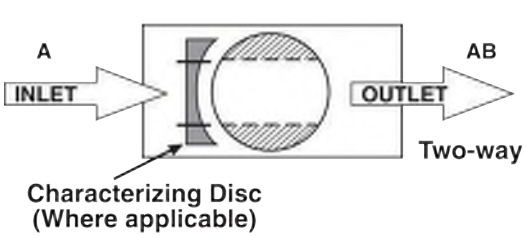
- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov

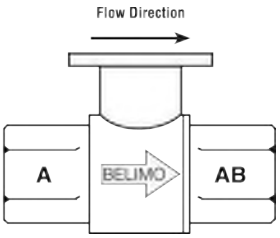
Product features

Application

This valve is typically used in air handling units on heating or cooling coils, and fan coil unit heating or cooling coils. Some other common applications include Unit Ventilators, VAV box re-heat coils and bypass loops. This valve is suitable for use in a hydronic system with variable flow.

Flow/Mounting details

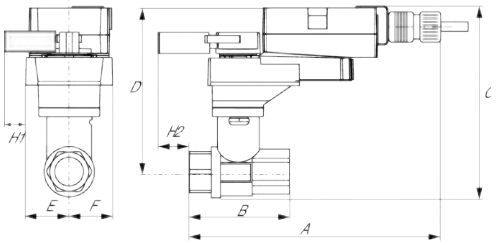




Dimensions

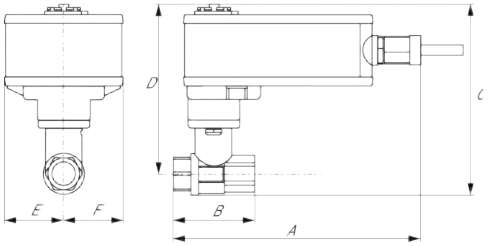
Dimensional drawings

LRB, LRX



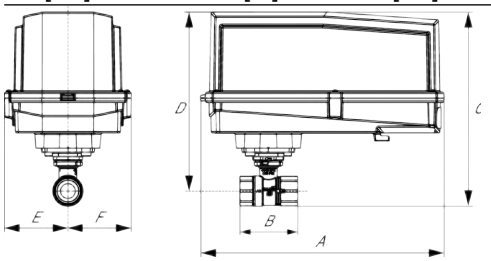
A	B	C	D	E	F	H1	H2
9.4" [239]	3.1" [78]	7.2" [184]	6.3" [161]	1.3" [33]	1.3" [33]	1.2" [30]	0.9" [23]

LF



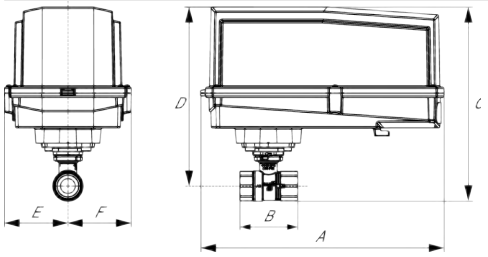
A	B	C	D	E	F
8.1" [206]	3.1" [78]	6.5" [165]	5.6" [142]	1.8" [46]	1.8" [46]

ARB N4, ARX N4, NRB N4, NRX N4



A	B	C	D	E	F
11.4" [289]	3.1" [78]	7.8" [199]	7.1" [181]	3.1" [80]	3.1" [80]

ARB N4, ARX N4, NRB N4, NRX N4



A	B	C	D	E	F
11.4" [289]	3.1" [78]	7.8" [199]	7.1" [181]	3.1" [80]	3.1" [80]

BELIMO

Modulating, Non-Spring Return, 24 V, for DC 2...10 V or 4...20 mA

Technical data sheet LRB24-SR

5-year warranty

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	1.5 W
	Power consumption in rest position	0.4 W
	Transformer sizing	3 VA (class 2 power source)
	Electrical Connection	18 GA plenum cable, 3 ft [1 m], with 1/2" conduit connector
	Overload Protection	electronic thoughout 0...90° rotation
Functional data	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for 2...10 V (0.1 mA), 500 Ω for 4...20 mA
	Position feedback U	2...10 V
	Direction of motion motor	selectable with switch 0/1
	Manual override	external push button
	Angle of rotation	90°
	Angle of rotation note	adjustable with mechanical stop
	Running Time (Motor)	90 s
	Noise level, motor	35 dB(A)
	Position indication	Mechanically, pluggable
Safety data	Degree of protection IEC/EN	IP54
	Degree of protection NEMA/UL	NEMA 2 UL Enclosure Type 2
	Agency Listing	cULus acc. to UL60730-1A/-2-14, CAN/CSA E60730-1:02, CE acc. to 2014/30/EU
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	1.1 lb [0.50 kg]

Safety notes

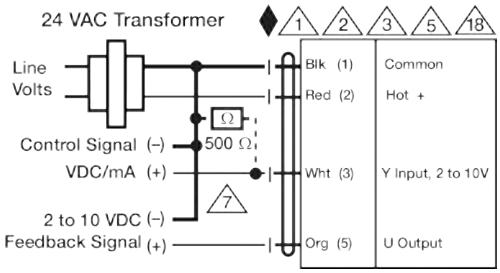
- Weather shield - PC w/ foam seal 16x8-3/8x4" (LxWxD).
- Classic GM to GMB(X) retrofit bracket.
- Battery Back Up System for SY(7~10)-110
- 120 to 24 VAC, 40 VA transformer.
- Cable for ZTH US to actuators w/o diagnostics socket.
- PC Tool computer programming interface, serial port.

Electrical installation

INSTALLATION NOTES

1 Provide overload protection and disconnect as required.
2 Actuators may be connected in parallel. Power consumption and input impedance must be observed.
3 Actuators may also be powered by 24 VDC.
5 Only connect common to negative (-) leg of control circuits.
7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.
18 Actuators with plenum cable do not have numbers; use color codes instead.
◆ Meets cULus requirements without the need of an electrical ground connection.

Warning! Live Electrical Components!
During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.



2...10 V / 4...20 mA Control

BELIMO

Stainless Steel Ball and Stem

Technical data sheet B225

5-year warranty

Technical data

Functional data	Valve Size	1" [25]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	0...250°F [-18...120°C]
	Body Pressure Rating	600 psi
	Close-off pressure Δps	200 psi
	Flow characteristic	equal percentage
	Servicing	maintenance-free
	Flow Pattern	2-way
	Leakage rate	0% for A – AB
	Controllable flow range	75°
	Cv	30
	Body pressure rating note	600 psi
	No Characterized Disc	TRUE
	Cv Flow Rating	A-port: as stated in chart B-port: 70% of A – AB Cv
Materials	Valve body	Nickel-plated brass body
	Stem seal	EPDM (lubricated)
	Seat	PTFE
	Pipe connection	NPT female ends
	O-ring	EPDM (lubricated)
	Ball	stainless steel
Suitable actuators	Non-Spring	LRB(X) NR

Safety notes

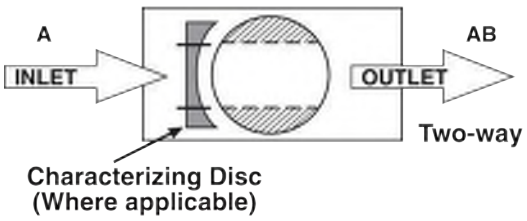
- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov

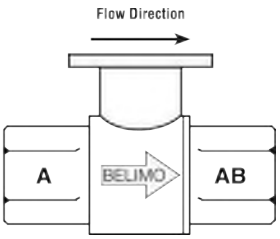
Product features

Application

This valve is typically used in air handling units on heating or cooling coils, and fan coil unit heating or cooling coils. Some other common applications include Unit Ventilators, VAV box re-heat coils and bypass loops. This valve is suitable for use in a hydronic system with variable flow.

Flow/Mounting details

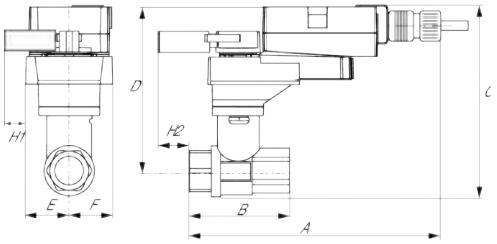




Dimensions

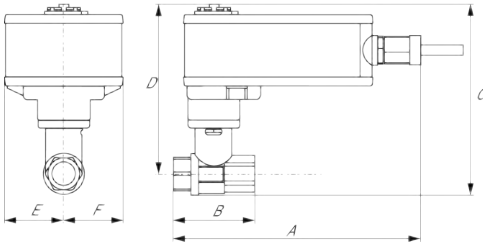
Dimensional drawings

LRB, LRX



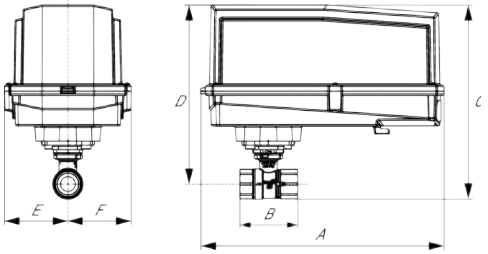
A	B	C	D	E	F	H1	H2
9.4" [239]	3.1" [78]	7.2" [184]	6.3" [161]	1.3" [33]	1.3" [33]	1.2" [30]	0.9" [23]

LF



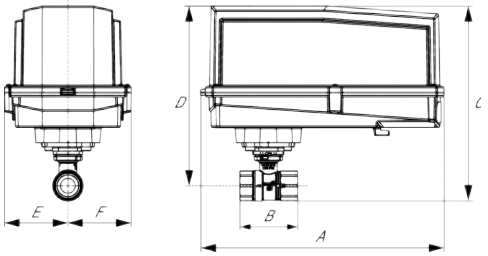
A	B	C	D	E	F
8.1" [206]	3.1" [78]	6.5" [165]	5.6" [142]	1.8" [46]	1.8" [46]

ARB N4, ARX N4, NRB N4, NRX N4



A	B	C	D	E	F
11.4" [289]	3.1" [78]	7.8" [199]	7.1" [181]	3.1" [80]	3.1" [80]

ARB N4, ARX N4, NRB N4, NRX N4



A	B	C	D	E	F
11.4" [289]	3.1" [78]	7.8" [199]	7.1" [181]	3.1" [80]	3.1" [80]

BELIMO

Modulating, Non-Spring Return, 24 V, for DC 2...10 V or 4...20 mA

Technical data sheet LRB24-SR

5-year warranty

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	1.5 W
	Power consumption in rest position	0.4 W
	Transformer sizing	3 VA (class 2 power source)
	Electrical Connection	18 GA plenum cable, 3 ft [1 m], with 1/2" conduit connector
	Overload Protection	electronic thoughout 0...90° rotation
Functional data	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for 2...10 V (0.1 mA), 500 Ω for 4...20 mA
	Position feedback U	2...10 V
	Direction of motion motor	selectable with switch 0/1
	Manual override	external push button
	Angle of rotation	90°
	Angle of rotation note	adjustable with mechanical stop
	Running Time (Motor)	90 s
	Noise level, motor	35 dB(A)
	Position indication	Mechanically, pluggable
Safety data	Degree of protection IEC/EN	IP54
	Degree of protection NEMA/UL	NEMA 2 UL Enclosure Type 2
	Agency Listing	cULus acc. to UL60730-1A/-2-14, CAN/CSA E60730-1:02, CE acc. to 2014/30/EU
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	1.1 lb [0.50 kg]

Safety notes

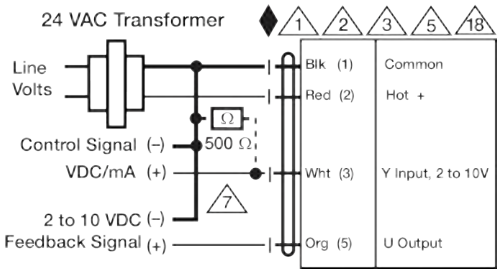
- Weather shield - PC w/ foam seal 16x8-3/8x4" (LxWxD).
- Classic GM to GMB(X) retrofit bracket.
- Battery Back Up System for SY(7~10)-110
- 120 to 24 VAC, 40 VA transformer.
- Cable for ZTH US to actuators w/o diagnostics socket.
- PC Tool computer programming interface, serial port.

Electrical installation

INSTALLATION NOTES

1 Provide overload protection and disconnect as required.
2 Actuators may be connected in parallel. Power consumption and input impedance must be observed.
3 Actuators may also be powered by 24 VDC.
5 Only connect common to negative (-) leg of control circuits.
7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.
18 Actuators with plenum cable do not have numbers; use color codes instead.
◆ Meets cULus requirements without the need of an electrical ground connection.

Warning! Live Electrical Components!
During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.



2...10 V / 4...20 mA Control

BELIMO

Stainless Steel Ball and Stem

Technical data sheet B239

5-year warranty

Technical data

Functional data	Valve Size	1.5" [40]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	0...250°F [-18...120°C]
	Body Pressure Rating	400 psi
	Close-off pressure Δps	200 psi
	Flow characteristic	equal percentage
	Servicing	maintenance-free
	Flow Pattern	2-way
	Leakage rate	0% for A – AB
	Controllable flow range	75°
	Cv	29
	Body pressure rating note	400 psi
	Cv Flow Rating	A-port: as stated in chart B-port: 70% of A – AB Cv
Materials	Valve body	Nickel-plated brass body
	Stem seal	EPDM (lubricated)
	Seat	PTFE
	Pipe connection	NPT female ends
	O-ring	EPDM (lubricated)
	Ball	stainless steel
Suitable actuators	Non-Spring	ARB(X) NRQB(X)

Safety notes

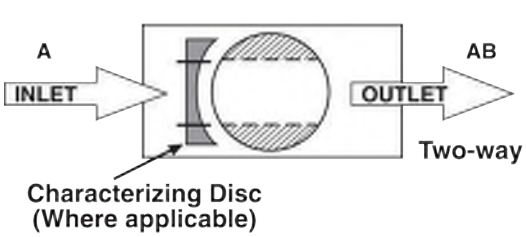
- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov

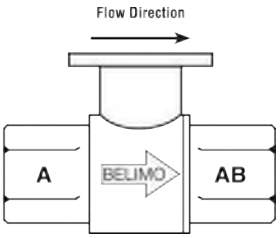
Product features

Application

This valve is typically used in air handling units on heating or cooling coils, and fan coil unit heating or cooling coils. Some other common applications include Unit Ventilators, VAV box re-heat coils and bypass loops. This valve is suitable for use in a hydronic system with variable flow.

Flow/Mounting details

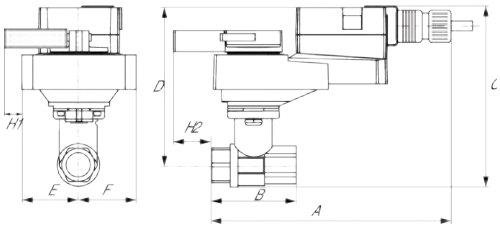




Dimensions

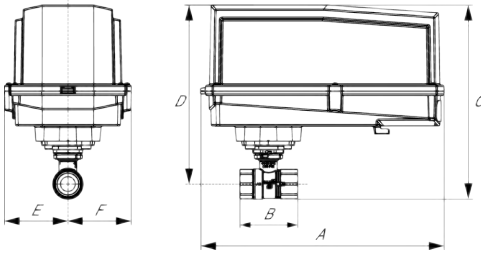
Dimensional drawings

ARB, ARX



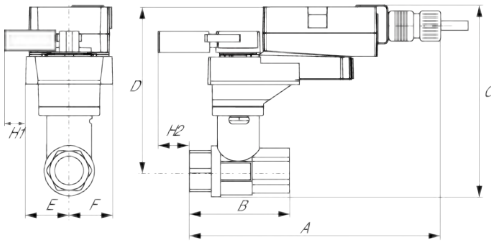
A	B	C	D	E	F	H1	H2
11.0" [280]	3.9" [100]	6.4" [163]	5.3" [134]	1.7" [44]	1.7" [44]	1.2" [30]	0.6" [15]

ARB N4, ARX N4, NRB N4, NRX N4



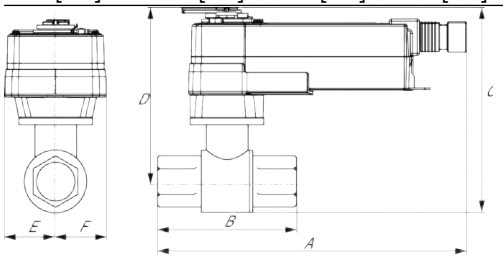
A	B	C	D	E	F
11.4" [289]	3.9" [100]	8.5" [217]	7.3" [185]	3.1" [80]	3.1" [80]

NRQB, NRQX



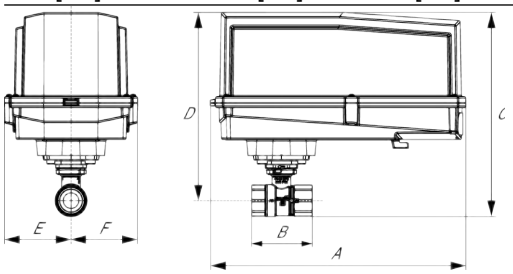
A	B	C	D	E	F	H1	H2
11.0" [280]	3.9" [100]	7.1" [181]	6.0" [152]	1.7" [44]	1.7" [44]	1.4" [34]	0.6" [15]

AFRB, AFRX



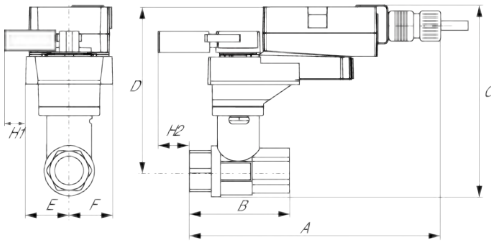
A	B	C	D	E	F
10.8" [275]	3.9" [100]	9.0" [229]	7.8" [198]	2.0" [51]	2.0" [51]

AFRB N4, AFRX N4



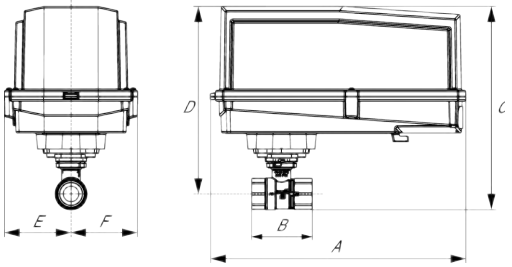
A	B	C	D	E	F
13.0" [330]	3.9" [100]	10.3" [262]	8.5" [216]	3.4" [86]	3.4" [86]

NRQB, NRQX



A	B	C	D	E	F	H1	H2
11.0" [280]	3.9" [100]	7.1" [181]	6.0" [152]	1.7" [44]	1.7" [44]	1.4" [34]	0.6" [15]

AFRB N4, AFRX N4



A	B	C	D	E	F
13.0" [330]	3.9" [100]	10.3" [262]	8.5" [216]	3.4" [86]	3.4" [86]

BELIMO

Modulating, Spring Return, AC 24 V for DC 2...10 V or 4...20 mA Control Signal

Technical data sheet AFRB24-SR

5-year warranty

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	5.5 W
	Power consumption in rest position	3 W
	Transformer sizing	8.5 VA (class 2 power source)
	Electrical Connection	18 GA appliance cable, 3 ft [1 m], with 1/2" conduit connector
	Overload Protection	electronic throughout 0...95° rotation
Functional data	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for 2...10 V (0.1 mA), 500 Ω for 4...20 mA
	Position feedback U	2...10 V
	Position feedback U note	Max. 0.5 mA
	Direction of motion motor	selectable with switch
	Direction of motion fail-safe	reversible with cw/ccw mounting
	Manual override	5 mm hex crank (3/16" Allen), supplied
	Angle of rotation	90°
	Running Time (Motor)	95 s
	Running time fail-safe	<20 s
	Noise level, motor	45 dB(A)
	Noise level, fail-safe	62 dB(A)
	Position indication	Mechanical
Safety data	Degree of protection IEC/EN	IP54
	Degree of protection NEMA/UL	NEMA 2 UL Enclosure Type 2
	Agency Listing	cULus acc. to UL60730-1A/-2-14, CAN/CSA E60730-1:02, CE acc. to 2014/30/EU and 2014/35/EU; Listed to UL 2043 - suitable for use in air plenums per Section 300.22(c) of the NEC and Section 602.2 of the IMC
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	5.4 lb [2.4 kg]

Electrical installation

INSTALLATION NOTES

Ⓐ Actuators with appliance cables are numbered.

△1 Provide overload protection and disconnect as required.

△3 Actuators may also be powered by 24 VDC.

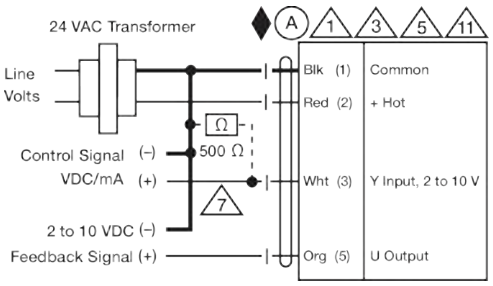
△5 Only connect common to negative (-) leg of control circuits.

△7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.

△11 Actuators may be connected in parallel if not mechanically linked. Power consumption and input impedance must be observed.

◆ Meets cULus requirements without the need of an electrical ground connection.

△! **Warning! Live Electrical Components!**
During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.



2...10 V / 4...20 mA Control

BELIMO

Stainless Steel Ball and Stem

Technical data sheet B240

5-year warranty

Technical data

Functional data	Valve Size	1.5" [40]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	0...250°F [-18...120°C]
	Body Pressure Rating	400 psi
	Close-off pressure Δps	200 psi
	Flow characteristic	equal percentage
	Servicing	maintenance-free
	Flow Pattern	2-way
	Leakage rate	0% for A – AB
	Controllable flow range	75°
	Cv	37
	Body pressure rating note	400 psi
	No Characterized Disc	TRUE
	Cv Flow Rating	A-port: as stated in chart B-port: 70% of A – AB Cv
Materials	Valve body	Nickel-plated brass body
	Stem seal	EPDM (lubricated)
	Seat	PTFE
	Pipe connection	NPT female ends
	O-ring	EPDM (lubricated)
	Ball	stainless steel
Suitable actuators	Non-Spring	ARB(X) NRQB(X)

Safety notes

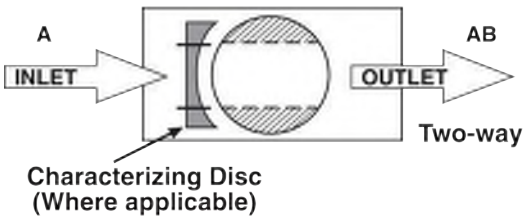
- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov

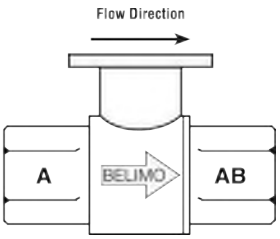
Product features

Application

This valve is typically used in air handling units on heating or cooling coils, and fan coil unit heating or cooling coils. Some other common applications include Unit Ventilators, VAV box re-heat coils and bypass loops. This valve is suitable for use in a hydronic system with variable flow.

Flow/Mounting details

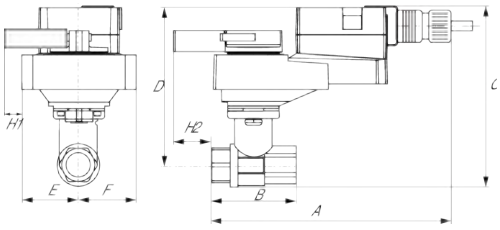




Dimensions

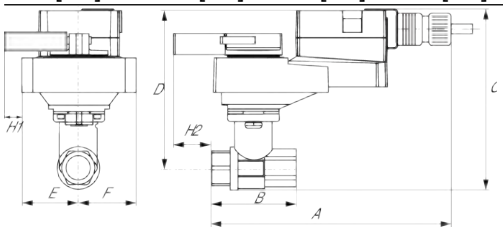
Dimensional drawings

ARB, ARX



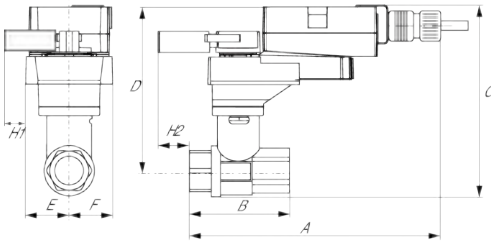
A	B	C	D	E	F	H1	H2
11.0" [280]	3.9" [100]	6.4" [163]	5.3" [134]	1.7" [44]	1.7" [44]	1.2" [30]	0.6" [15]

ARB, ARX 120-3, 120-SR, MFT



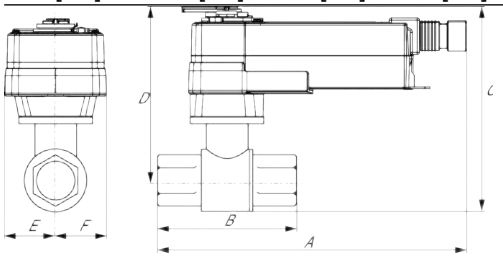
A	B	C	D	E	F	H1	H2
11.0" [280]	3.9" [100]	6.4" [163]	5.3" [134]	1.7" [44]	1.7" [44]	1.2" [30]	0.6" [15]

NRQB, NRQX



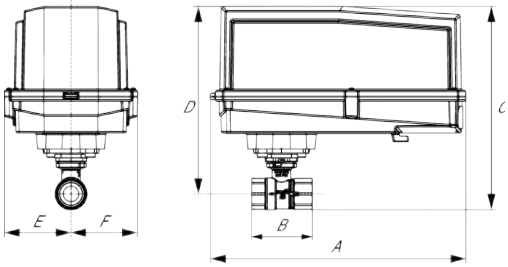
A	B	C	D	E	F	H1	H2
11.0" [280]	3.9" [100]	7.1" [181]	6.0" [152]	1.7" [44]	1.7" [44]	1.4" [34]	0.6" [15]

AFRB, AFRX



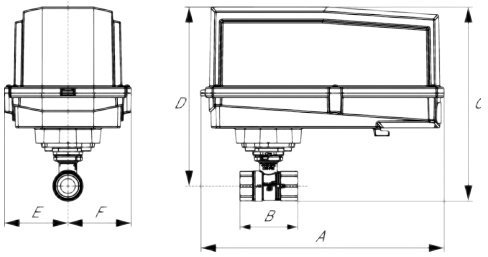
A	B	C	D	E	F
10.8" [275]	3.9" [100]	9.0" [229]	7.8" [198]	2.0" [51]	2.0" [51]

AFRB N4, AFRX N4



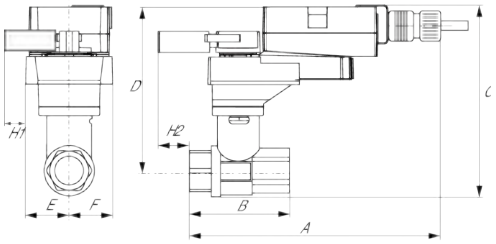
A	B	C	D	E	F
13.0" [330]	3.9" [100]	10.3" [262]	8.5" [216]	3.4" [86]	3.4" [86]

ARB N4, ARX N4, NRB N4, NRX N4



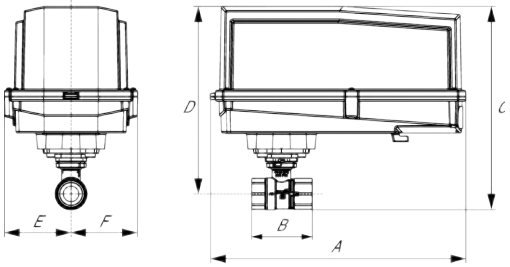
A	B	C	D	E	F
11.4" [289]	3.9" [100]	8.5" [217]	7.3" [185]	3.1" [80]	3.1" [80]

NRQB, NRQX



A	B	C	D	E	F	H1	H2
11.0" [280]	3.9" [100]	7.1" [181]	6.0" [152]	1.7" [44]	1.7" [44]	1.4" [34]	0.6" [15]

AFRB N4, AFRX N4



A	B	C	D	E	F
13.0" [330]	3.9" [100]	10.3" [262]	8.5" [216]	3.4" [86]	3.4" [86]

BELIMO

Modulating, Non-Spring Return, 24 V, for DC 2...10 V or 4...20 mA

Technical data sheet ARB24-SR

5-year warranty

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	2.5 W
	Power consumption in rest position	0.4 W
	Transformer sizing	5 VA (class 2 power source)
	Electrical Connection	18 GA plenum cable, 3 ft [1 m], with 1/2" conduit connector
	Overload Protection	electronic thoughout 0...90° rotation
Functional data	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for 2...10 V (0.1 mA), 500 Ω for 4...20 mA
	Position feedback U	2...10 V
	Direction of motion motor	selectable with switch 0/1
	Manual override	external push button
	Angle of rotation	90°
	Angle of rotation note	adjustable with mechanical stop
	Running Time (Motor)	90 s
	Noise level, motor	45 dB(A)
	Position indication	Mechanically, pluggable
Safety data	Degree of protection IEC/EN	IP54
	Degree of protection NEMA/UL	NEMA 2 UL Enclosure Type 2
	Agency Listing	cULus acc. to UL60730-1A/-2-14, CAN/CSA E60730-1:02, CE acc. to 2014/30/EU
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	2.2 lb [1.0 kg]

Safety notes

- NEMA 4X, 316L stainless steel enclosure.
- Battery Back Up System for SY(7~10)-110
- ZS-300 without brackets.
- Terminal-strip cover for NEMA 2 rating (-T models).
- MFT95 resistor kit for 4 to 20 mA control applications.
- Battery Back Up System for SY(10~12)-220P

Electrical installation

INSTALLATION NOTES

1 Provide overload protection and disconnect as required.

2 Actuators may be connected in parallel. Power consumption and input impedance must be observed.

5 Only connect common to negative (-) leg of control circuits.

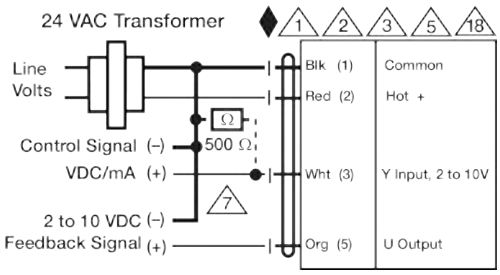
7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.

18 Actuators with plenum cable do not have numbers; use color codes instead.

Meets cULus requirements without the need of an electrical ground connection.

Warning! Live Electrical Components!

During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.



2...10 V / 4...20 mA Control

BELIMO

Stainless Steel Ball and Stem

Technical data sheet B249

5-year warranty

Technical data

Functional data	Valve Size	2" [50]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	0...250°F [-18...120°C]
	Body Pressure Rating	400 psi
	Close-off pressure Δps	200 psi
	Flow characteristic	equal percentage
	Servicing	maintenance-free
	Flow Pattern	2-way
	Leakage rate	0% for A – AB
	Controllable flow range	75°
	Cv	46
	Body pressure rating note	400 psi
Materials	Valve body	Nickel-plated brass body
	Stem seal	EPDM (lubricated)
	Seat	PTFE
	Pipe connection	NPT female ends
	O-ring	EPDM (lubricated)
	Ball	stainless steel
Suitable actuators	Non-Spring	ARB(X)

Safety notes

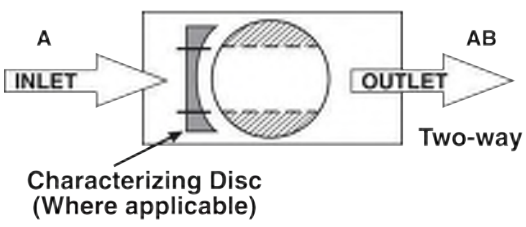
- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov

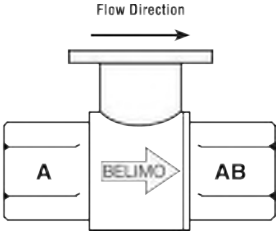
Product features

Application

This valve is typically used in air handling units on heating or cooling coils, and fan coil unit heating or cooling coils. Some other common applications include Unit Ventilators, VAV box re-heat coils and bypass loops. This valve is suitable for use in a hydronic system with variable flow.

Flow/Mounting details

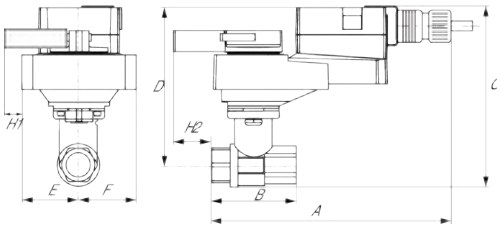




Dimensions

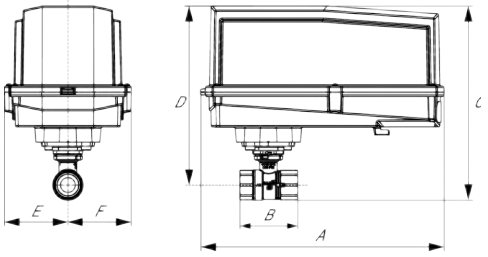
Dimensional drawings

ARB, ARX



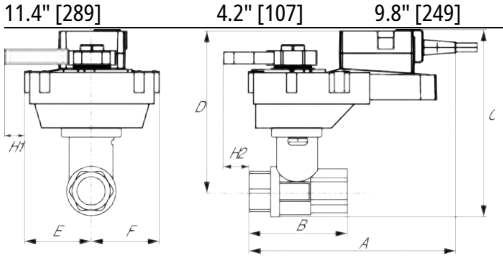
A	B	C	D	E	F	H1	H2
11.0" [280]	4.2" [107]	6.9" [175]	5.5" [140]	1.7" [44]	1.7" [44]	1.2" [30]	0.6" [15]

ARB N4, ARX N4, NRB N4, NRX N4



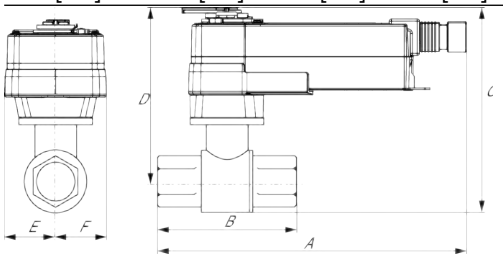
A	B	C	D	E	F
11.4" [289]	4.2" [107]	9.8" [249]	7.6" [194]	3.1" [80]	3.1" [80]

ARQB, ARQX



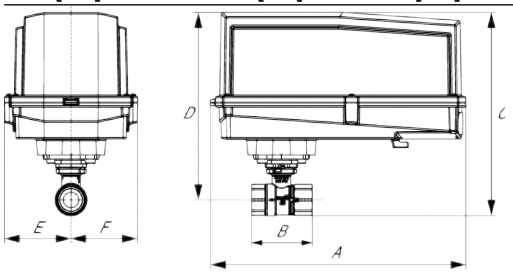
A	B	C	D	E	F	H1	H2
11.0" [280]	4.2" [107]	7.5" [191]	6.1" [155]	2.3" [58]	2.3" [58]	0.8" [20]	0.6" [15]

AFRB, AFRX



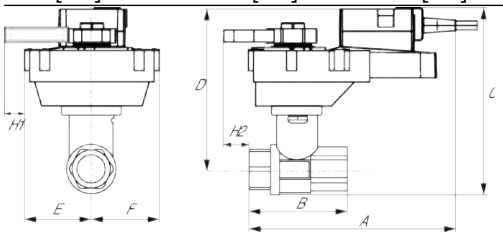
A	B	C	D	E	F
10.8" [275]	4.2" [107]	9.5" [241]	8.1" [206]	2.0" [51]	2.0" [51]

AFRB N4, AFRX N4



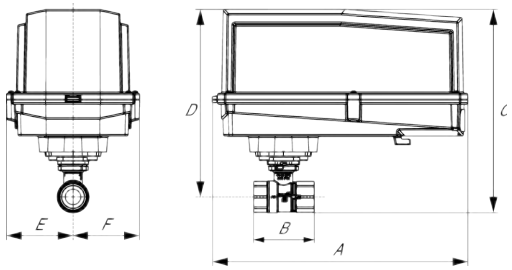
A	B	C	D	E	F
13.0" [330]	4.9" [125]	10.3" [262]	9.3" [235]	3.4" [86]	3.4" [86]

ARQB, ARQX



A	B	C	D	E	F	H1	H2
11.0" [280]	4.2" [107]	7.5" [191]	6.1" [155]	2.3" [58]	2.3" [58]	0.8" [20]	0.6" [15]

AFRB N4, AFRX N4



A	B	C	D	E	F
13.0" [330]	4.9" [125]	10.3" [262]	9.3" [235]	3.4" [86]	3.4" [86]

BELIMO

Modulating, Spring Return, AC 24 V for DC 2...10 V or 4...20 mA Control Signal

Technical data sheet AFRB24-SR

5-year warranty

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	5.5 W
	Power consumption in rest position	3 W
	Transformer sizing	8.5 VA (class 2 power source)
	Electrical Connection	18 GA appliance cable, 3 ft [1 m], with 1/2" conduit connector
	Overload Protection	electronic throughout 0...95° rotation
Functional data	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for 2...10 V (0.1 mA), 500 Ω for 4...20 mA
	Position feedback U	2...10 V
	Position feedback U note	Max. 0.5 mA
	Direction of motion motor	selectable with switch
	Direction of motion fail-safe	reversible with cw/ccw mounting
	Manual override	5 mm hex crank (3/16" Allen), supplied
	Angle of rotation	90°
	Running Time (Motor)	95 s
	Running time fail-safe	<20 s
	Noise level, motor	45 dB(A)
	Noise level, fail-safe	62 dB(A)
	Position indication	Mechanical
Safety data	Degree of protection IEC/EN	IP54
	Degree of protection NEMA/UL	NEMA 2 UL Enclosure Type 2
	Agency Listing	cULus acc. to UL60730-1A/-2-14, CAN/CSA E60730-1:02, CE acc. to 2014/30/EU and 2014/35/EU; Listed to UL 2043 - suitable for use in air plenums per Section 300.22(c) of the NEC and Section 602.2 of the IMC
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	5.4 lb [2.4 kg]

Electrical installation

INSTALLATION NOTES

Ⓐ Actuators with appliance cables are numbered.

△1 Provide overload protection and disconnect as required.

△3 Actuators may also be powered by 24 VDC.

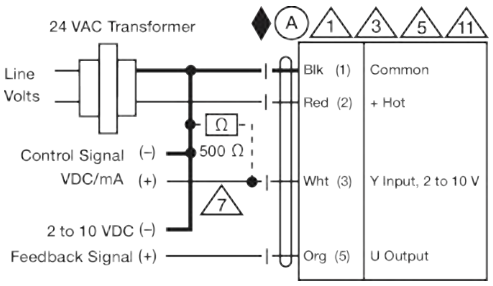
△5 Only connect common to negative (-) leg of control circuits.

△7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.

△11 Actuators may be connected in parallel if not mechanically linked. Power consumption and input impedance must be observed.

◆ Meets cULus requirements without the need of an electrical ground connection.

△! **Warning! Live Electrical Components!**
During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.



2...10 V / 4...20 mA Control

5-year warranty

Technical data

Functional data	Valve Size	2" [50]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	0...250°F [-18...120°C]
	Body Pressure Rating	400 psi
	Close-off pressure Δps	200 psi
	Flow characteristic	equal percentage
	Servicing	maintenance-free
	Flow Pattern	2-way
	Leakage rate	0% for A – AB
	Controllable flow range	75°
	Cv	65
	Body pressure rating note	400 psi
	Cv Flow Rating	A-port: as stated in chart B-port: 70% of A – AB Cv
Materials	Valve body	Nickel-plated brass body
	Stem seal	EPDM (lubricated)
	Seat	PTFE
	Pipe connection	NPT female ends
	O-ring	EPDM (lubricated)
	Ball	stainless steel
Suitable actuators	Non-Spring	ARB(X)

Safety notes

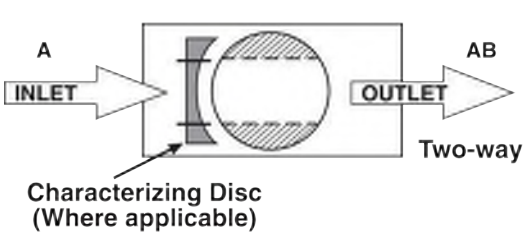
- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov

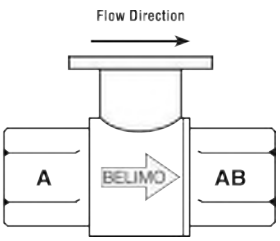
Product features

Application

This valve is typically used in air handling units on heating or cooling coils, and fan coil unit heating or cooling coils. Some other common applications include Unit Ventilators, VAV box re-heat coils and bypass loops. This valve is suitable for use in a hydronic system with variable flow.

Flow/Mounting details

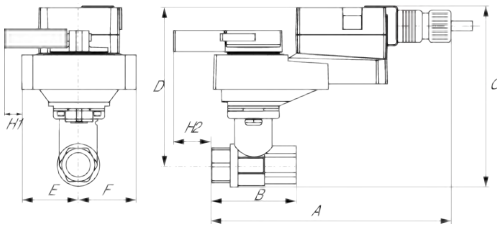




Dimensions

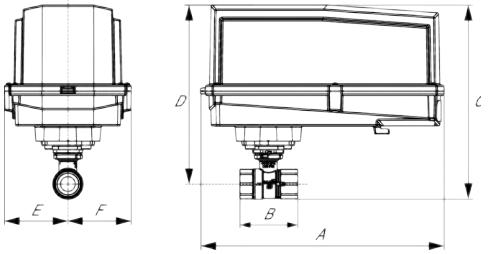
Dimensional drawings

ARB, ARX



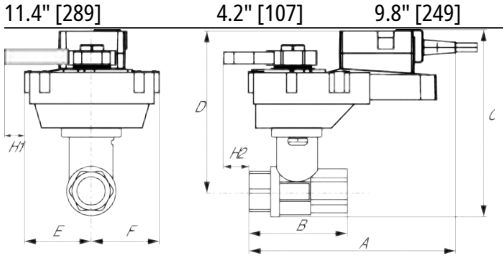
A	B	C	D	E	F	H1
10.2" [260]	4.9" [125]	7.7" [196]	6.0" [152]	1.7" [44]	1.7" [44]	1.2" [30]

ARB N4, ARX N4, NRB N4, NRX N4



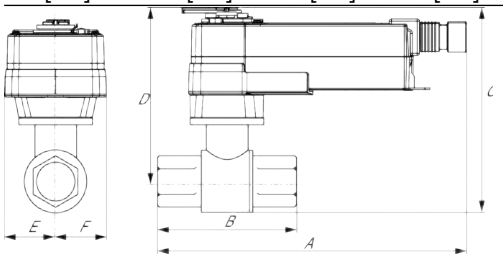
A	B	C	D	E	F
11.4" [289]	4.2" [107]	9.8" [249]	7.6" [194]	3.1" [80]	3.1" [80]

ARQB, ARQX



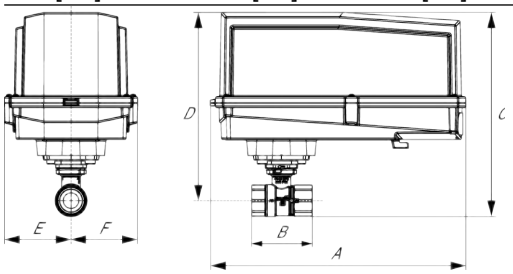
A	B	C	D	E	F	H1	H2
9.9" [251]	4.2" [107]	7.5" [191]	6.1" [155]	2.3" [58]	2.3" [58]	0.8" [20]	0.6" [15]

AFRB, AFRX



A	B	C	D	E	F
11.3" [286]	4.9" [125]	10.6" [268]	8.9" [225]	2.0" [51]	2.0" [51]

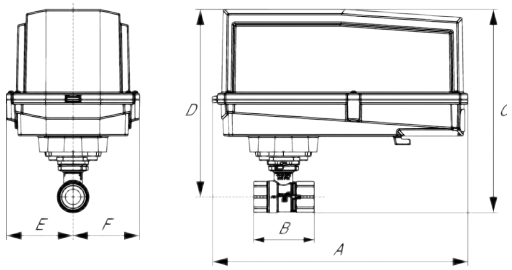
AFRB N4, AFRX N4



A	B	C	D	E	F
13.0" [330]	4.9" [125]	10.3" [262]	9.3" [235]	3.4" [86]	3.4" [86]

A	B	C	D	E	F	H1	H2
9.9" [251]	4.2" [107]	7.5" [191]	6.1" [155]	2.3" [58]	2.3" [58]	0.8" [20]	0.6" [15]

AFRB N4, AFRX N4



A	B	C	D	E	F
13.0" [330]	4.9" [125]	10.3" [262]	9.3" [235]	3.4" [86]	3.4" [86]

BELIMO

Modulating, Non-Spring Return, 24 V, Multi-Function Technology®

Technical data sheet ARX24-MFT

5-year warranty

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	3.5 W
	Power consumption in rest position	1.3 W
	Transformer sizing	6 VA (class 2 power source)
	Electrical Connection	18 GA plenum cable with 1/2" conduit connector, degree of protection NEMA 2 / IP54, 3 ft [1 m] 10 ft [3 m] and 16ft [5 m]
	Overload Protection	electronic thoughout 0...90° rotation
Functional data	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for 2...10 V (0.1 mA), 500 Ω for 4...20 mA, 1500 Ω for PWM, On/Off and Floating point
	Operating range Y variable	Start point 0.5...30 V End point 2.5...32 V
	Options positioning signal	variable (VDC, on/off, floating point)
	Position feedback U	2...10 V
	Position feedback U note	Max. 0.5 mA
	Position feedback U variable	VDC variable
	Direction of motion motor	selectable with switch 0/1
	Manual override	external push button
	Angle of rotation	90°
	Angle of rotation note	adjustable with mechanical stop
	Running Time (Motor)	default 150 s, variable 90...150 s
	Running time motor variable	90...150 s
	Noise level, motor	45 dB(A)
	Position indication	Mechanically, pluggable
Safety data	Degree of protection IEC/EN	IP54
	Degree of protection NEMA/UL	NEMA 2 UL Enclosure Type 2
	Agency Listing	cULus acc. to UL60730-1A/-2-14, CAN/CSA E60730-1:02, CE acc. to 2014/30/EU
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	2.6 lb [1.2 kg]

Safety notes

- PVC W'Shld for GV w/UGLK (GM)
- Battery Back Up System for SY(7~10)-110
- 120 to 24 VAC, 40 VA transformer.
- Cable for ZTH US to actuators w/o diagnostics socket.
- 50% voltage divider kit (resistors with wires).
- PC Tool computer programming interface, serial port.

Accessories

Gateways	Description	Type
	Gateway MP to BACnet MS/TP	UK24BAC
	Gateway MP to LonWorks	UK24LON
	Gateway MP to Modbus RTU	UK24MOD

Service tools	Description	Type
	Connection cable 10 ft [3 m], A: RJ11 6/4 ZTH EU, B: 3-pin Weidmüller and supply connection	ZK4-GEN
	Service Tool, with ZIP-USB function, for parametrisable and communicative Belimo actuators, VAV controller and HVAC performance devices	ZTH US

Electrical installation

INSTALLATION NOTES

1 Provide overload protection and disconnect as required.

2 Actuators may be connected in parallel. Power consumption and input impedance must be observed.

3 Actuators may also be powered by 24 VDC.

5 Only connect common to negative (-) leg of control circuits.

7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.

8 Control signal may be pulsed from either the Hot (Source) or Common (Sink) 24 V line.

10 For triac sink the Common connection from the actuator must be connected to the Hot connection of the controller. Position feedback cannot be used with a triac sink controller; the actuator internal common reference is not compatible.

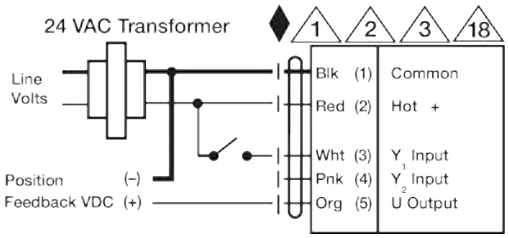
12 IN4004 or IN4007 diode. (IN4007 supplied, Belimo part number 40155).

18 Actuators with plenum cable do not have numbers; use color codes instead.

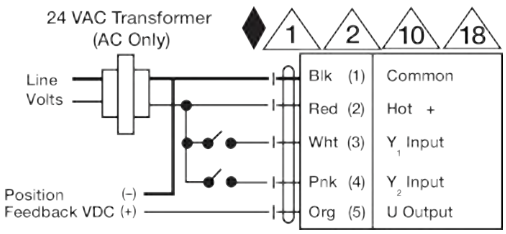
Meets cULus requirements without the need of an electrical ground connection.

Warning! Live Electrical Components!

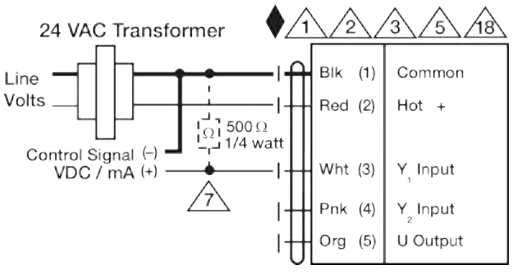
During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.



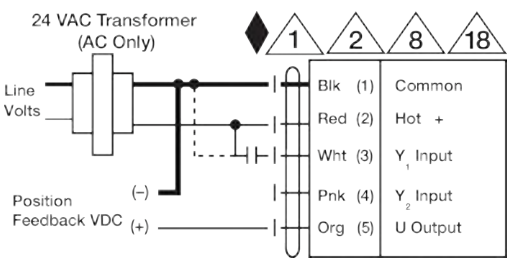
On/Off



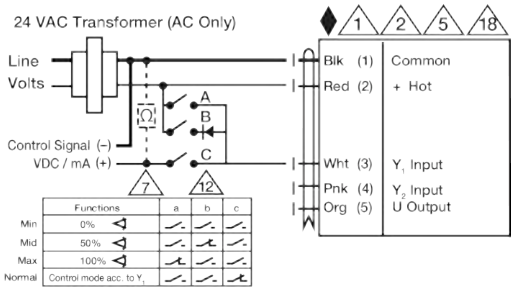
Floating Point



VDC/mA Control



PWM Control



Override Control

BELIMO

Stainless Steel Ball and Stem

Technical data sheet B325

5-year warranty

Technical data

Functional data	Valve Size	1" [25]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	0...250°F [-18...120°C]
	Body Pressure Rating	600 psi
	Close-off pressure Δps	200 psi
	Flow characteristic	A-port equal percentage, B-port modified for constant common port flow
	Servicing	maintenance-free
	Flow Pattern	3-way Mixing/Diverting
	Leakage rate	0% for A – AB, <2.0% for B – AB
	Controllable flow range	75°
	Cv	30
	Body pressure rating note	600 psi
	No Characterized Disc	TRUE
	Cv Flow Rating	A-port: as stated in chart B-port: 70% of A – AB Cv
Materials	Valve body	Nickel-plated brass body
	Stem seal	EPDM (lubricated)
	Seat	PTFE
	Pipe connection	NPT female ends
	O-ring	EPDM (lubricated)
	Ball	stainless steel
Suitable actuators	Non-Spring	LRB(X) NRB(X) N4

Safety notes

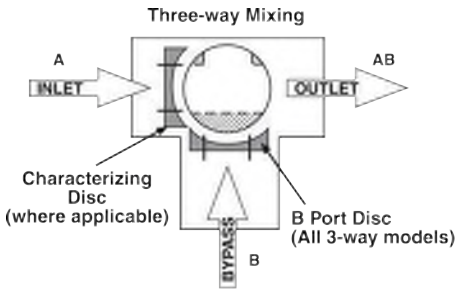
- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov

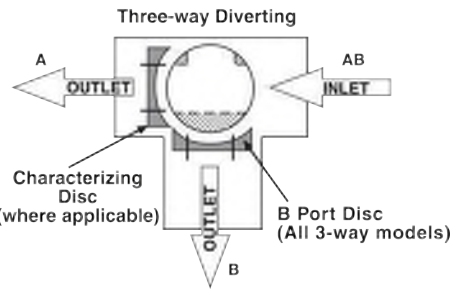
Product features

Application

This valve is typically used in air handling units on heating or cooling coils, and fan coil unit heating or cooling coils. Some other common applications include Unit Ventilators, VAV box re-heat coils and bypass loops. This valve is suitable for use in a hydronic system with variable or constant flow.

Flow/Mounting details

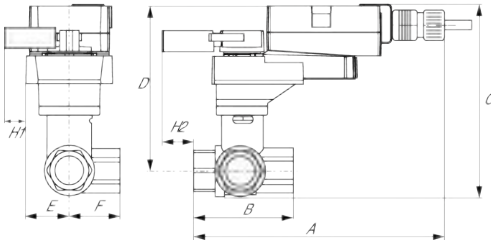




Dimensions

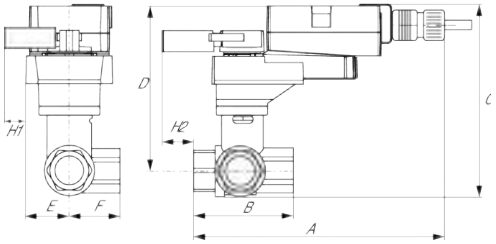
Dimensional drawings

LRB, LRX



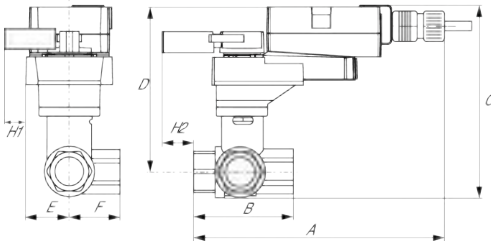
A	B	C	D	E	F	H1	H2
8.5" [216]	3.1" [78]	5.9" [150]	5.1" [129]	1.3" [33]	1.6" [40]	1.2" [30]	0.9" [23]

LRB, LRX



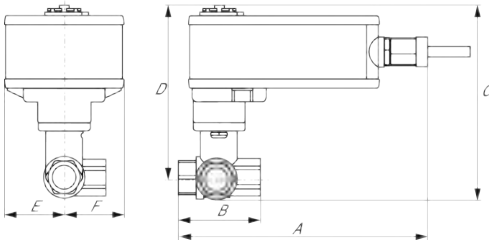
A	B	C	D	E	F	H1	H2
9.4" [239]	3.1" [78]	7.2" [184]	6.3" [161]	1.3" [33]	1.3" [33]	1.2" [30]	0.9" [23]

LRQB, LRQX



A	B	C	D	E	F	H1	H2
8.9" [226]	3.1" [78]	6.7" [169]	5.6" [142]	1.6" [40]	1.6" [40]	1.2" [30]	1" [25]

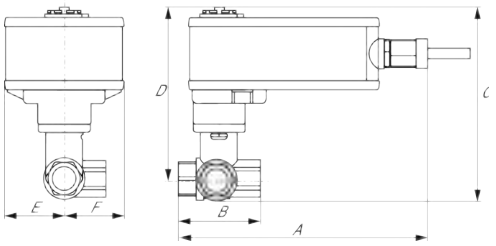
LF



A	B	C	D	E	F
8.1" [206]	3.1" [78]	6.5" [165]	5.6" [142]	1.9" [48]	1.9" [48]

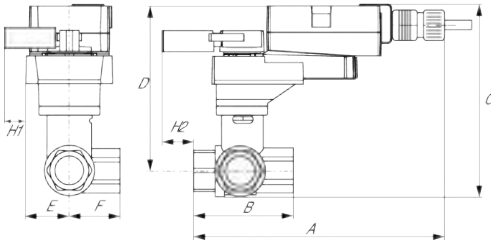
A	B	C	D	E	F
8.1" [206]	3.1" [78]	6.5" [165]	5.6" [142]	1.9" [48]	1.9" [48]

LF



A	B	C	D	E	F	H1	H2
8.9" [226]	3.1" [78]	6.7" [169]	5.6" [142]	1.6" [40]	1.6" [40]	1.2" [30]	1" [25]

LRQB, LRQX



BELIMO

Technical data sheet LF24-SR US

Modulating, Spring Return, AC 24 V/DC, for DC 2...10 V or 4...20 mA Control Signal

Proportional, Spring Return, 24 V for 2 to 10 VDC or 4 to 20 mA Control Signal, Torque min. 35 in-lb, for control of air dampers

5-year warranty

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	2.5 W
	Power consumption in rest position	1 W
	Transformer sizing	5 VA (class 2 power source)
	Electrical Connection	18 GA plenum cable, 3 ft [1 m], with 1/2" conduit connector
	Overload Protection	electronic throughout 0...95° rotation
	Electrical Protection	actuators are double insulated
Functional data	Torque motor	35 in-lb [4 Nm]
	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for 2...10 V (0.1 mA), 500 Ω for 4...20 mA
	Position feedback U	2...10 V
	Position feedback U note	Max. 0.7 mA
	Direction of motion motor	selectable with switch 0/1
	Direction of motion fail-safe	reversible with cw/ccw mounting
	Angle of rotation	Max. 95°,
	Running Time (Motor)	150 s constant, independent of load
	Running time motor note	constant, independent of load
	Running time fail-safe	<25 s @ -4...122°F [-20...50°C], <60 s @ -22°F [-30°C]
	Noise level, motor	30 dB(A)
	Noise level, fail-safe	62 dB(A)
	Shaft Diameter	3/8...1/2" round, centers on 1/2"
	Position indication	Mechanical
Safety data	Degree of protection IEC/EN	IP54
	Degree of protection NEMA/UL	NEMA 2 UL Enclosure Type 2
	Agency Listing	cULus acc. To UL 873 and CAN/CSA C22.2 No. 24-93
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	3.4 lb [1.5 kg]
Materials	Housing material	galvanized steel

Product features

Application

For fail-safe, modulating control of dampers in HVAC systems. Actuator sizing should be done in accordance with the damper manufacturer's specifications. The actuator is mounted directly to a damper shaft from 3/8" up to 1/2" in diameter by means of its universal clamp, 1/2" shaft centered at delivery. For shafts up to 3/4" use K6-1 accessory. A crank arm and several mounting brackets are available for applications where the actuator cannot be direct coupled to the damper shaft. The actuator operates in response to a 2 to 10 VDC, or with the addition of a 500Ω resistor, a 4 to 20 mA control input from an electronic controller or positioner. A 2 to 10 VDC feedback signal is provided for position indication.

Operation

The LF series actuators provide true spring return operation for reliable fail-safe application and positive close-off on air tight dampers. The spring return system provides consistent torque to the damper with, and without, power applied to the actuator. The LF series provides 95° of rotation and is provided with a graduated position indicator showing 0 to 95°. The LF24-SR US uses a brushless DC motor which is controlled by an Application Specific Integrated Circuit (ASIC) and a microprocessor. The microprocessor provides the intelligence to the ASIC to provide a constant rotation rate and to know the actuator's exact fail-safe position. The ASIC monitors and controls the brushless DC motor's rotation and provides a digital rotation sensing function to prevent damage to the actuator in a stall condition. The actuator may be stalled anywhere in its normal rotation without the need of mechanical end switches. Power consumption is reduced in holding mode.

Typical specification

Spring return control damper actuators shall be direct coupled type which require no crank arm and linkage and be capable of direct mounting to a shaft up to a 3/4" diameter and center on a 1/2" shaft (default). Actuator shall deliver a minimum output torque of 35 in-lbs. The actuator must provide modulating damper control in response to a 2 to 10 VDC or, with the addition of a 500Ω resistor, a 4 to 20 mA control input from an electronic controller. Actuators shall use a brushless DC motor controlled by a microprocessor and be protected from overload at all angles of rotation. Run time shall be constant, and independent of torque. A 2 to 10 feedback signal shall be provided for position feedback. The actuator must be designed so that they may be used for either clockwise or counter clockwise failsafe operation. Actuators shall be cULus listed, have a 5 year warranty, and be manufactured under ISO 9001 International Quality Control Standards. Actuators shall be as manufactured by Belimo.

Accessories

Electrical accessories

Description	Type
DC Voltage Input Rescaling Module	IRM-100
Auxiliary switch, mercury-free	P475
Auxiliary switch, mercury-free	P475-1
Signal Siumlator, Power supply AC 230 V	PS-100
Convert Pulse Width Modulated Signal to a 2...10 V Signal for Belimo Proportional Actuators	PTA-250
Positioner for wall mounting	SGA24
Positioner for front-panel mounting	SGF24
Resistor, 500 Ω, 1/4" wire resistor with 6" pigtail wires	ZG-R01
Resistor Kit, 50% voltage divider	ZG-R02
Mounting plate for SGF.	ZG-SGF
Transformer, AC 120 V to AC 24 V, 40 VA	ZG-X40

Mechanical accessories

Description	Type
Shaft extension 170 mm Ø10 mm for damper shaft Ø 6...16 mm	AV6-20
End stop indicator	IND-LF
Shaft clamp for LF..	K6 US
Shaft clamp reversible, clamping range Ø16...20 mm	K6-1
Ball joint suitable for damper crank arm KH8 / KH10	KG10A
Ball joint suitable for damper crank arm KH8	KG6
Ball joint suitable for damper crank arm KH8	KG8
Actuator arm, clamping range Ø8...16 mm, Slot width 8.2 mm	KH-LF
V-bolt Kit for KH-LF.	KH-LFV
Damper crank arm Slot width 8.2 mm, for Ø1.05"	KH12
Damper crank arm Slot width 6.2 mm, clamping range Ø10...18 mm	KH6
Damper crank arm Slot width 8.2 mm, clamping range Ø10...18 mm	KH8
Anti-rotation bracket LF.	LF-P
Push rod for KG10A ball joint (36" L, 3/8" diameter).	SH10
Push rod for KG6 & KG8 ball joints (36" L, 5/16" diameter).	SH8
Wrench 8 mm and 10 mm	TOOL-06

Angle of rotation limiter, with end stop	ZDB-LF
Form fit adapter 8x8 mm	ZF8-LF
Mounting Bracket: ZS-260 Right Angle	ZG-109
Linkage kit	ZG-110
Mounting bracket for LF..	ZG-112
Damper clip for damper blade, 3.5" width.	ZG-DC1
Damper clip for damper blade, 6" width.	ZG-DC2
LF crankarm adaptor kit (includes ZG-112).	ZG-LF112
LF crankarm adaptor kit (T bracket included).	ZG-LF2
Shaft extension for 3/8" diameter shafts (4" L).	ZG-LMSA-1
Shaft extension for 1/2" diameter shafts (5" L).	ZG-LMSA-1/2-5
Weather shield 13x8x6" [330x203x152 mm] (LxWxH)	ZS-100
Base Plate, for ZS-100	ZS-101
Weather shield 16x8-3/8x4" [406x213x102 mm] (LxWxH)	ZS-150
Explosion Proof Housing 16x10x6.435" [406x254x164 mm] (LxWxH), UL and CSA, Class I, Zone 1&2, Groups B, C, D, (NEMA 7), Class III, Hazardous (classified) Locations	ZS-260
Weather shield 17-1/4x8-3/4x5-1/2" [438x222x140 mm] (LxWxH), NEMA 4X, with mounting brackets	ZS-300
Weather shield 17-1/4x8-3/4x5-1/2" [438x222x140 mm] (LxWxH), NEMA 4X, with mounting brackets	ZS-300-5
Shaft extension 1/2"	ZS-300-C1
Shaft extension 3/4"	ZS-300-C2
Shaft extension 1"	ZS-300-C3

Electrical installation

Warning! Live Electrical Components!
During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.

◆ Meets cULus requirements without the need of an electrical ground connection.

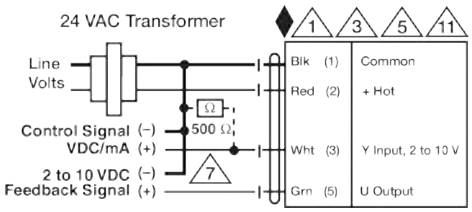
1 Provide overload protection and disconnect as required.

3 Actuators may also be powered by 24 VDC.

5 Only connect common to negative (-) leg of control circuits.

7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.

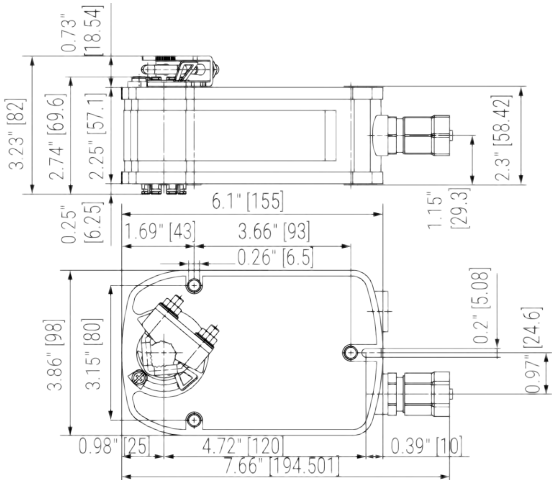
11 Actuators may be connected in parallel if not mechanically linked. Power consumption and input impedance must be observed.



2...10 V / 4...20 mA Control

Dimensions

Dimensional drawings



BELIMO

Stainless Steel Ball and Stem

Technical data sheet B349

5-year warranty

Technical data

Functional data	Valve Size	2" [50]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	0...250°F [-18...120°C]
	Body Pressure Rating	400 psi
	Close-off pressure Δps	200 psi
	Flow characteristic	A-port equal percentage, B-port modified for constant common port flow
	Servicing	maintenance-free
	Flow Pattern	3-way Mixing/Diverting
	Leakage rate	0% for A – AB, <2.0% for B – AB
	Controllable flow range	75°
	Cv	46
	Body pressure rating note	400 psi
	Cv Flow Rating	A-port: as stated in chart B-port: 70% of A – AB Cv
Materials	Valve body	Nickel-plated brass body
	Stem seal	EPDM (lubricated)
	Seat	PTFE
	Pipe connection	NPT female ends
	O-ring	EPDM (lubricated)
	Ball	stainless steel
Suitable actuators	Non-Spring	ARB(X)

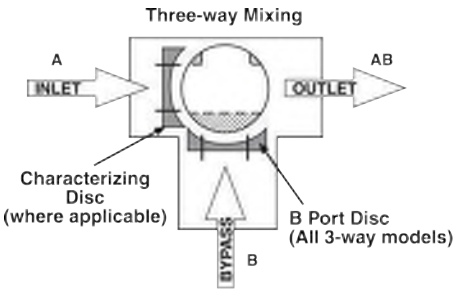
Safety notes

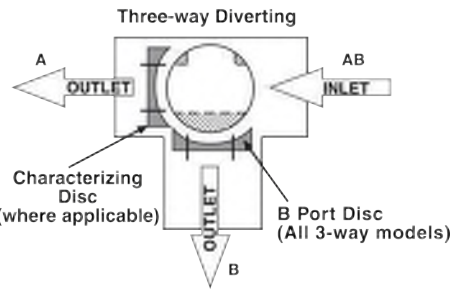
- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov

Product features

Application This valve is typically used in air handling units on heating or cooling coils, and fan coil unit heating or cooling coils. Some other common applications include Unit Ventilators, VAV box re-heat coils and bypass loops. This valve is suitable for use in a hydronic system with variable or constant flow.

Flow/Mounting details

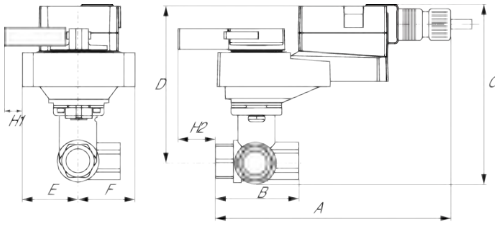




Dimensions

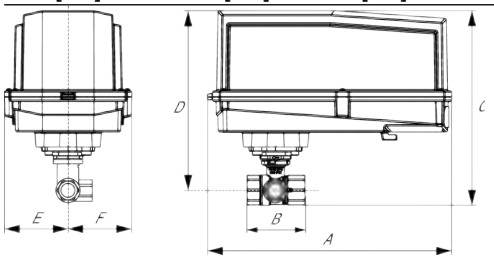
Dimensional drawings

ARB, ARX



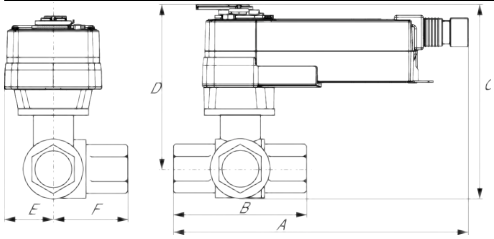
A	B	C	D	E	F	H1
10.5" [267]	4.9" [125]	7.7" [196]	6.0" [152]	1.7" [44]	2.6" [66]	0.8" [20]

ARB N4, ARX N4



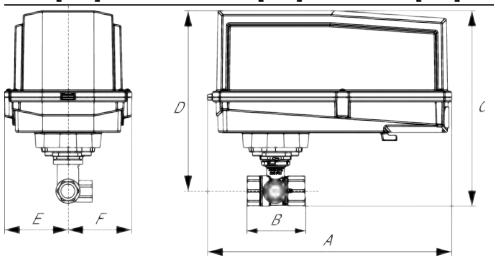
A	B	C	D	E	F
11.4" [289]	4.9" [125]	9.8" [249]	8.0" [203]	3.1" [80]	3.1" [80]

AFRB, AFRX



A	B	C	D	E	F
11.3" [286]	4.9" [125]	8.3" [211]	6.6" [168]	2.6" [66]	2.6" [66]

AFRB N4, AFRX N4



A	B	C	D	E	F
13.0" [330]	4.9" [125]	11.8" [300]	9.9" [251]	3.7" [95]	3.7" [95]

BELIMO

Modulating, Spring Return, AC 24 V for DC 2...10 V or 4...20 mA Control Signal

Technical data sheet AFRB24-SR

5-year warranty

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	5.5 W
	Power consumption in rest position	3 W
	Transformer sizing	8.5 VA (class 2 power source)
	Electrical Connection	18 GA appliance cable, 3 ft [1 m], with 1/2" conduit connector
	Overload Protection	electronic throughout 0...95° rotation
Functional data	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for 2...10 V (0.1 mA), 500 Ω for 4...20 mA
	Position feedback U	2...10 V
	Position feedback U note	Max. 0.5 mA
	Direction of motion motor	selectable with switch
	Direction of motion fail-safe	reversible with cw/ccw mounting
	Manual override	5 mm hex crank (3/16" Allen), supplied
	Angle of rotation	90°
	Running Time (Motor)	95 s
	Running time fail-safe	<20 s
	Noise level, motor	45 dB(A)
	Noise level, fail-safe	62 dB(A)
	Position indication	Mechanical
Safety data	Degree of protection IEC/EN	IP54
	Degree of protection NEMA/UL	NEMA 2 UL Enclosure Type 2
	Agency Listing	cULus acc. to UL60730-1A/-2-14, CAN/CSA E60730-1:02, CE acc. to 2014/30/EU and 2014/35/EU; Listed to UL 2043 - suitable for use in air plenums per Section 300.22(c) of the NEC and Section 602.2 of the IMC
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	5.4 lb [2.4 kg]

Electrical installation

INSTALLATION NOTES

Ⓐ Actuators with appliance cables are numbered.

△1 Provide overload protection and disconnect as required.

△3 Actuators may also be powered by 24 VDC.

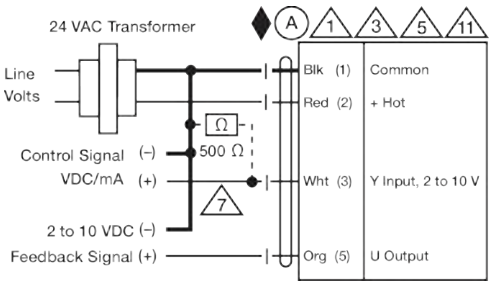
△5 Only connect common to negative (-) leg of control circuits.

△7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.

△11 Actuators may be connected in parallel if not mechanically linked. Power consumption and input impedance must be observed.

◆ Meets cULus requirements without the need of an electrical ground connection.

△! **Warning! Live Electrical Components!**
During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.



2...10 V / 4...20 mA Control

5-year warranty

Technical data

Functional data	Valve Size	0.5" [15]
	Fluid	chilled or hot water, up to 60% glycol
	Fluid Temp Range (water)	36...212°F [2...100°C]
	Body Pressure Rating	360 psi
	Close-off pressure Δps	75 psi
	Flow characteristic	equal percentage
	Servicing	maintenance-free
	Flow Pattern	2-way
	Leakage rate	0%
	Controllable flow range	75°
	Cv	5.9
	Body pressure rating note	360 psi
Materials	Valve body	forged brass
	Seat	PTFE
	Pipe connection	NPT female ends
	O-ring	EPDM (lubricated)
	Ball	chrome plated brass
Suitable actuators	Non-Spring	CQB
	Electronic fail-safe	CQKB(X)

Safety notes

- WARNING: This product can expose you to lead which is known to the State of California to cause cancer and reproductive harm. For more information go to www.p65warnings.ca.gov
- * If temperature exceeds 212°F operating range due to a boiler control failure the valve will safely contain the hot water but manufacturers product warranty becomes invalid. Valve and actuator replacement is at the expense of others.

Product features

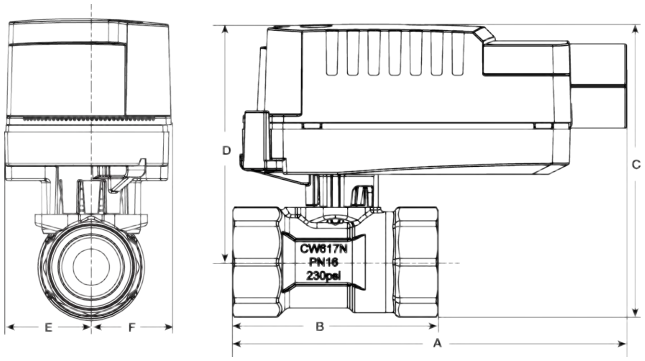
Application

The QCV zone valves are suited for large commercial buildings where higher close-off and the ability to change flow is desired. Common applications include unit ventilators, fan coil units, VAV reheat coils, fin tube casing, radiant panels and duct coils. The valve fits in space restricted areas and can be assembled without the use of tools.

Dimensions

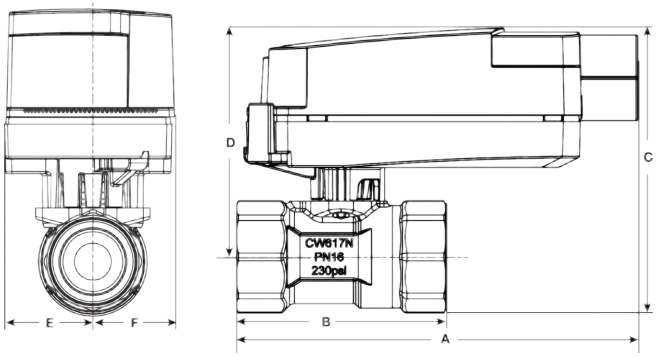
Dimensional drawings

CQK



A	B	C	D	E	F
4.5" [114]	2.0" [52]	3.3" [83]	2.7" [69]	0.9" [24]	0.9" [24]

CQ



A	B	C	D	E	F
4.5" [114]	2.0" [52]	3.1" [80]	2.6" [65]	1.0" [25]	1.0" [26]

BELIMO

Modulating, Non-Spring Return, 24 V, DC 2 V (Close) DC 10 V (Open) or 4...20 mA

Technical data sheet CQB24-SR-R

5-year warranty

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	0.4 W
	Power consumption in rest position	0.3 W
	Transformer sizing	1 VA (class 2 power source)
	Electrical Connection	18 GA plenum cable, 3 ft [1 m], with 1/2" conduit connector
	Overload Protection	electronic thoughout 0...90° rotation
Functional data	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Position feedback U	2...10 V
	Angle of rotation	90°, adjustable with mechanical stop
	Angle of rotation note	adjustable with mechanical stop
	Running Time (Motor)	75 s
	Noise level, motor	35 dB(A)
	Position indication	pointer
Safety data	Degree of protection IEC/EN	IP40
	Degree of protection NEMA/UL	NEMA 2 UL Enclosure Type 2
	Agency Listing	cULus acc. to UL60730-1A/-2-14, CAN/CSA E60730-1:02, CE acc. to 2014/30/EU and 2014/35/EU; Listed to UL 2043 - suitable for use in air plenums per Section 300.22(c) of the NEC and Section 602.2 of the IMC
	Quality Standard	ISO 9001
	Ambient temperature	35...104°F [1.7...40°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing
	Servicing	maintenance-free
Weight	Weight	0.55 lb [0.20 kg]
Materials	Housing material	UL94-5VA

Product features

Application

Non-Fail Safe proportional ZoneTight actuator.

Valve selection should be done in accordance with the flow parameters and system specifications.

The actuator is mounted directly to the valve without the need for tools or additional linkage.

The actuator operates in response to a 2...10 V or 4...20mA control signal.

Electrical installation

INSTALLATION NOTES

2 Actuators may be connected in parallel. Power consumption and input impedance must be observed.

3 Actuators may also be powered by 24 VDC.

5 Only connect common to negative (-) leg of control circuits.

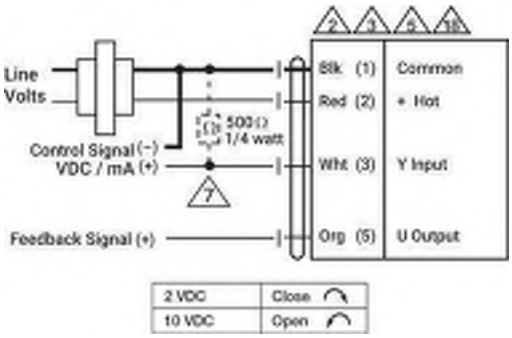
7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.

18 Actuators with plenum cable do not have numbers; use color codes instead.

Meets cULus requirements without the need of an electrical ground connection.

Warning! Live Electrical Components!

During installation, testing, servicing and troubleshooting of this product, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.



AC 24 V Transformer

BELIMO

Modulating, Spring Return, AC 24 V/DC, for DC 2...10 V or 4...20 mA Control Signal

Technical data sheet AFB24-SR

5-year warranty

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	5.5 W
	Power consumption in rest position	3 W
	Transformer sizing	8.5 VA (class 2 power source)
	Electrical Connection	18 GA appliance cable, 3 ft [1 m], with 1/2" conduit connector
	Overload Protection	electronic throughout 0...95° rotation
	Electrical Protection	actuators are double insulated
Functional data	Torque motor	180 in-lb [20 Nm]
	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for 2...10 V (0.1 mA), 500 Ω for 4...20 mA
	Position feedback U	2...10 V
	Position Feedback	2...10 V, Max. 0.5 mA
	Position feedback U note	Max. 0.5 mA
	Direction of motion motor	selectable with switch 0/1
	Direction of motion fail-safe	reversible with cw/ccw mounting
	Manual override	5 mm hex crank (3/16" Allen), supplied
	Angle of rotation	95°, adjustable with mechanical end stop, 35...95°
	Angle of rotation note	adjustable with mechanical end stop, 35...95°
	Running Time (Motor)	95 s
	Running time fail-safe	<20 s @ -4...122°F [-20...50°C], <60 s @ -22°F [-30°C]
	Running time fail-safe note	@ -4...122°F [-20...50°C], <60 s @ -22°F [-30°C]
	Noise level, motor	40 dB(A)
	Noise level, fail-safe	62 dB(A)
	Shaft Diameter	1/2...1.05" round, centers on 1/2" and 3/4" with insert, 1.05" without insert
	Position indication	Mechanical
Safety data	Degree of protection IEC/EN	IP54
	Degree of protection NEMA/UL	NEMA 2
	Enclosure	UL Enclosure Type 2
	Agency Listing	cULus listed to UL60730-1A:02; UL 60730-2-14:02 and CAN/CSA-E60730-1:02; Listed to UL 2043 - suitable for use in air plenums per Section 300.22(c) of the NEC and Section 602.2 of the IMC
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing

	Servicing	maintenance-free
Weight	Weight	4.1 lb [1.9 kg]
Materials	Housing material	Galvanized steel and plastic housing

Product features

Application

For fail-safe, modulating control of dampers in HVAC systems. Actuator sizing should be done in accordance with the damper manufacturer's specifications. The actuator is mounted directly to a damper shaft up to 1.05" in diameter by means of its universal clamp. A crank arm and several mounting brackets are available for applications where the actuator cannot be direct coupled to the damper shaft. The actuator operates in response to a DC 2...10 Vor, with the addition of a 500Ω resistor, a 4...20 mA control input from an electronic controller or positioner. A DC 2...10 V feedback signal is provided for position indication.

A common installation technique for control of multi-section dampers is to use the U5 position feedback of one actuator (Master) to control multiple actuators (Slaves). Belimo refers to this as Master/Slave control. The only requirement is that the actuators are installed on MECHANICALLY SEPARATE damper shafts.

Operation

The AF..24-SR series actuators provide true spring return operation for reliable fail-safe application and positive close off on air tight dampers. The spring return system provides constant torque to the damper with, and without, power applied to the actuator. The AF..24-SR series provides 95° of rotation and is provided with a graduated position indicator showing 0° to 95°. The AF..24-SR uses a brushless DC motor which is controlled by an Application Specific Integrated Circuit (ASIC) and a microprocessor. The microprocessor provides the intelligence to the ASIC to provide a constant rotation rate and to know the actuator's exact fail-safe position. The ASIC monitors and controls the brushless DC motor's rotation and provides a digital rotation sensing function to prevent damage to the actuator in a stall condition. The actuator may be stalled anywhere in its normal rotation without the need of mechanical end switches. The AF..24-SR actuator is shipped at 5° (5° from full fail-safe) to provide automatic compression against damper gaskets for tight shut-off.

ATTENTION: AF..24-SR cannot be tandem mounted on the same damper or valve shaft. Only On/Off and MFT AF.. models can be used for tandem mount applications.

Typical specification

Spring return control damper actuators shall be direct coupled type which require no crank arm and linkage and be capable of direct mounting to a jackshaft up to a 1.05" diameter. The actuator must provide modulating damper control in response to a 2 to 10 VDC or, with the addition of a 500Ω resistor, a 4 to 20 mA control input from an electronic controller or positioner. The actuators must be designed so that they may be used for either clockwise or counter clockwise fail-safe operation. Actuators shall use a brushless DC motor controlled by a microprocessor and be protected from overload at all angles of rotation. Run time shall be constant, and independent of torque. A 2 to 10 VDC feedback signal shall be provided for position feedback. Actuators with auxiliary switches must be constructed to meet the requirements for Double Insulation so an electrical ground is not required to meet agency listings. Actuators shall be cULus listed and have a 5 year warranty, and be manufactured under ISO 9001 International Quality Control Standards. Actuators shall be as manufactured by Belimo.

Accessories

Electrical accessories	**Description**	**Type**
		IRM-100
	Auxiliary switch, mercury-free	P475
	Auxiliary switch, mercury-free	P475-1
	Signal Siumlator, Power supply AC 230 V	PS-100
		PTA-250
	Positioner for wall mounting	SGA24
	Positioner for front-panel mounting	SGF24
	Cable Conduit Connector 1/2"	TF-CC US
	Resistor, 500 Ω, 1/4" wire resistor with 6" pigtail wires	ZG-R01
	Resistor Kit, 50% voltage divider	ZG-R02
	Mounting plate for SGF.	ZG-SGF
	Transformer, AC 120 V to AC 24 V, 40 VA	ZG-X40

Mechanical accessories	**Description**	**Type**
	Anti-rotation bracket AF/NF.	AF-P
	Shaft extension 240 mm Ø20 mm for damper shaft Ø 8...22.7 mm	AV8-25

End stop indicator	IND-AFB
Shaft clamp reversible, for central mounting, for damper shafts Ø12.7 / 19.0 / 25.4 mm	K7-2
Ball joint suitable for damper crank arm KH8 / KH10	KG10A
Ball joint suitable for damper crank arm KH8	KG8
Actuator arm, for 3/4" shafts, clamping range Ø10...22 mm, Slot width 8.2 mm	KH-AFB
Damper crank arm Slot width 8.2 mm, clamping range Ø14...25 mm	KH10
Damper crank arm Slot width 8.2 mm, for Ø1.05"	KH12
Damper crank arm Slot width 8.2 mm, clamping range Ø10...18 mm	KH8
Push rod for KG10A ball joint (36" L, 3/8" diameter).	SH10
Push rod for KG6 & KG8 ball joints (36" L, 5/16" diameter).	SH8
TOOL-06 8mm-10mm Wrench	TOOL-06
Retrofit clip	Z-AF
Base plate extension	Z-SF
Univ. right angle bracket 17"x11-1/8"x6" (HxWxbase).	ZG-100
Univ. right angle bracket 13x11x7-7/16" (HxWxbase).	ZG-101
Right angle bracket for ZS-260.	ZG-109
Stand-off bracket for ZS-260.	ZG-110
AFB(X)/NFB(X) U bracket 5-7/8x5-1/2x2-19/32" (HxWxD).	ZG-118
Jackshaft mounting bracket.	ZG-120
Mounting kit for linkage operation for flat and side installation	ZG-AFB
Mounting kit for foot mount installation	ZG-AFB118
Damper clip for damper blade, 3.5" width.	ZG-DC1
Damper clip for damper blade, 6" width.	ZG-DC2
1" diameter jackshaft adaptor (11" L).	ZG-JSA-1
1-5/16" diameter jackshaft adaptor (12" L).	ZG-JSA-2
1.05" diameter jackshaft adaptor (12" L).	ZG-JSA-3
Weather shield 13x8x6" [330x203x152 mm] (LxWxH)	ZS-100
Base Plate, for ZS-100	ZS-101
Weather shield 16x8-3/8x4" [406x213x102 mm] (LxWxH)	ZS-150
Explosion Proof Housing 16x10x6.435" [406x254x164 mm] (LxWxH), UL and CSA, Class I, Zone 1&2, Groups B, C, D, (NEMA 7), Class III, Hazardous (classified) Locations, outdoor application NEMA 4	ZS-260
Weather shield 17-1/4x8-3/4x5-1/2" [438x222x140 mm] (LxWxH), NEMA 4X, with mounting brackets	ZS-300
Weather shield 17-1/4x8-3/4x5-1/2" [438x222x140 mm] (LxWxH), NEMA 4X, with mounting brackets	ZS-300-5
Shaft extension 1/2"	ZS-300-C1
Shaft extension 3/4"	ZS-300-C2
Shaft extension 1"	ZS-300-C3

Electrical installation

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Meets cULus requirements without the need of an electrical ground connection.

A Actuators with appliance cables are numbered.

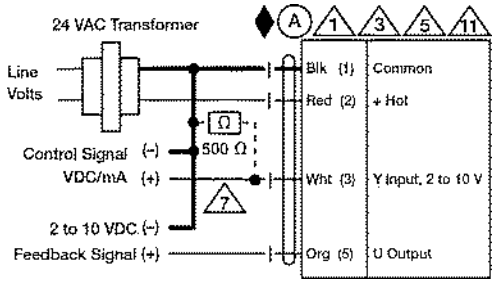
1 Provide overload protection and disconnect as required.

3 Actuators may also be powered by 24 VDC.

5 Only connect common to negative (-) leg of control circuits.

7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.

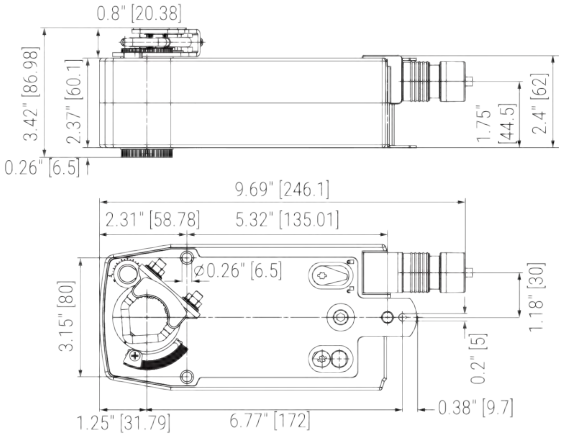
11 Actuators may be connected in parallel if not mechanically linked. Power consumption and input impedance must be observed.



2...10 V / 4...20 mA Control

Dimensions

Dimensional drawings



BELIMO

Modulating, Spring Return, AC 24 V for DC 2...10 V or 4...20 mA Control Signal

Technical data sheet LF24-SR US

5-year warranty

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	2.5 W
	Power consumption in rest position	1 W
	Transformer sizing	5 VA (class 2 power source)
	Electrical Connection	18 GA plenum cable, 3 ft [1 m], with 1/2" conduit connector
	Overload Protection	electronic throughout 0...95° rotation
Functional data	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for 2...10 V (0.1 mA), 500 Ω for 4...20 mA
	Position feedback U	2...10 V
	Position feedback U note	Max. 0.7 mA
	Direction of motion motor	selectable with switch 0/1
	Direction of motion fail-safe	reversible with cw/ccw mounting
	Angle of rotation	90°
	Running Time (Motor)	150 s constant, independent of load
	Running time motor note	constant, independent of load
	Running time fail-safe	<25 s @ -4...122°F [-20...50°C], <60 s @ -22°F [-30°C]
	Noise level, motor	50 dB(A)
	Noise level, fail-safe	62 dB(A)
	Position indication	Mechanical
Safety data	Degree of protection IEC/EN	IP54
	Degree of protection NEMA/UL	NEMA 2
	Enclosure	UL Enclosure Type 2
	Agency Listing	cULus acc. To UL 873 and CAN/CSA C22.2 No. 24-93
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% RH, non-condensing
	Servicing	maintenance-free
Weight	Weight	3.1 lbs (1.40 kg.)

Electrical installation

INSTALLATION NOTES

(A) Actuators with appliance cables are numbered.

1 Provide overload protection and disconnect as required.

3 Actuators may also be powered by DC 24 V.

5 Only connect common to negative (-) leg of control circuits.
7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.
11 Actuators may be connected in parallel if not mechanically linked. Power consumption and input impedance must be observed.

Meets cULus requirements without the need of an electrical ground connection.

Warning! Live electrical components!
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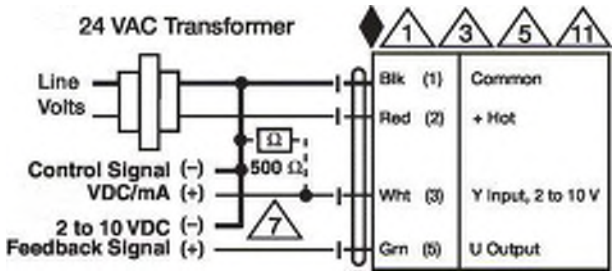
Wiring diagrams

2...10 V / 4...20 mA Control



BELIMO

Modulating, Spring Return, AC 24 V/DC, for DC 2...10 V or 4...20 mA Control Signal

Technical data sheet NFB24-SR

5-year warranty

Technical data

Electrical data	Nominal voltage	AC/DC 24 V
	Nominal voltage frequency	50/60 Hz
	Power consumption in operation	3.5 W
	Power consumption in rest position	2.5 W
	Transformer sizing	6 VA (class 2 power source)
	Electrical Connection	18 GA appliance cable, 3 ft [1 m], with 1/2" conduit connector
	Overload Protection	electronic throughout 0...95° rotation
	Electrical Protection	actuators are double insulated
Functional data	Torque motor	90 in-lb [10 Nm]
	Operating range Y	2...10 V
	Operating range Y note	4...20 mA w/ ZG-R01 (500 Ω, 1/4 W resistor)
	Input Impedance	100 kΩ for 2...10 V (0.1 mA), 500 Ω for 4...20 mA
	Position feedback U	2...10 V
	Position Feedback	2...10 V, Max. 0.5 mA
	Position feedback U note	Max. 0.5 mA
	Direction of motion motor	selectable with switch 0/1
	Direction of motion fail-safe	reversible with cw/ccw mounting
	Manual override	5 mm hex crank (3/16" Allen), supplied
	Angle of rotation	95°, adjustable with mechanical end stop, 35...95°
	Angle of rotation note	adjustable with mechanical end stop, 35...95°
	Running Time (Motor)	95 s
	Running time fail-safe	<20 s @ -4...122°F [-20...50°C], <60 s @ -22°F [-30°C]
	Running time fail-safe note	@ -4...122°F [-20...50°C], <60 s @ -22°F [-30°C]
	Noise level, motor	40 dB(A)
	Noise level, fail-safe	62 dB(A)
	Shaft Diameter	1/2...1.05" round, centers on 1/2" and 3/4" with insert, 1.05" without insert
	Position indication	Mechanical
Safety data	Degree of protection IEC/EN	IP54
	Degree of protection NEMA/UL	NEMA 2
	Enclosure	UL Enclosure Type 2
	Agency Listing	cULus listed to UL60730-1A:02; UL 60730-2-14:02 and CAN/CSA-E60730-1:02; Listed to UL 2043 - suitable for use in air plenums per Section 300.22(c) of the NEC and Section 602.2 of the IMC
	Quality Standard	ISO 9001
	Ambient temperature	-22...122°F [-30...50°C]
	Storage temperature	-40...176°F [-40...80°C]
	Ambient humidity	max. 95% r.H., non-condensing

	Servicing	maintenance-free
Weight	Weight	4.9 lb [2.2 kg]
Materials	Housing material	Galvanized steel and plastic housing

Product features

Application

For fail-safe, modulating control of dampers in HVAC systems. Actuator sizing should be done in accordance with the damper manufacturer's specifications. The actuator is mounted directly to a damper shaft up to 1.05" in diameter by means of its universal clamp. A crank arm and several mounting brackets are available for applications where the actuator cannot be direct coupled to the damper shaft. The actuator operates in response to a 2 to 10 VDC or, with the addition of a 500Ω resistor, a 4 to 20 mA control input from an electronic controller or positioner. A 2 to 10 VDC feedback signal is provided for position indication. Not to be used for a master-slave application.

Operation

The NF..24-SR series actuators provide true spring return operation for reliable fail-safe application and positive close off on air tight dampers. The spring return system provides constant torque to the damper with, and without, power applied to the actuator. The NF..24-SR series provides 95° of rotation and is provided with a graduated position indicator showing 0° to 95°. The NF..24-SR uses a brushless DC motor which is controlled by an Application Specific Integrated Circuit (ASIC) and a microprocessor. The microprocessor provides the intelligence to the ASIC to provide a constant rotation rate and to know the actuator's exact fail-safe position. The ASIC monitors and controls the brushless DC motor's rotation and provides a digital rotation sensing function to prevent damage to the actuator in a stall condition. The actuator may be stalled anywhere in its normal rotation without the need of mechanical end switches. The NF..24-SR actuator is shipped at 5° (5° from full fail-safe) to provide automatic compression against damper gaskets for tight shut-off.

Typical specification

Spring return control damper actuators shall be direct coupled type which require no crank arm and linkage and be capable of direct mounting to a jackshaft up to a 1.05" diameter. The actuator must provide modulating damper control in response to a 2 to 10 VDC or, with the addition of a 500Ω resistor, a 4 to 20 mA control input from an electronic controller or positioner. The actuators must be designed so that they may be used for either clockwise or counter clockwise fail-safe operation. Actuators shall use a brushless DC motor controlled by a microprocessor and be protected from overload at all angles of rotation. Run time shall be constant, and independent of torque. A 2 to 10 VDC feedback signal shall be provided for position feedback. Actuators with auxiliary switches must be constructed to meet the requirements for Double Insulation so an electrical ground is not required to meet agency listings. Actuators shall be cULus listed and have a 5 year warranty, and be manufactured under ISO 9001 International Quality Control Standards. Actuators shall be as manufactured by Belimo.

Accessories

Electrical accessories

Description	Type
	IRM-100
Auxiliary switch, mercury-free	P475
Auxiliary switch, mercury-free	P475-1
Signal Siumlator, Power supply AC 230 V	PS-100
	PTA-250
Positioner for wall mounting	SGA24
Positioner for front-panel mounting	SGF24
Cable Conduit Connector 1/2"	TF-CC US
Resistor, 500 Ω, 1/4" wire resistor with 6" pigtail wires	ZG-R01
Resistor Kit, 50% voltage divider	ZG-R02
Mounting plate for SGF.	ZG-SGF
Transformer, AC 120 V to AC 24 V, 40 VA	ZG-X40

Mechanical accessories

Description	Type
Anti-rotation bracket AF/NF.	AF-P
Shaft extension 240 mm Ø20 mm for damper shaft Ø 8...22.7 mm	AV8-25
End stop indicator	IND-AFB
Shaft clamp reversible, for central mounting, for damper shafts Ø12.7 / 19.0 / 25.4 mm	K7-2
Ball joint suitable for damper crank arm KH8 / KH10	KG10A
Ball joint suitable for damper crank arm KH8	KG8

Actuator arm, for 3/4" shafts, clamping range Ø10...22 mm, Slot width 8.2 mm	KH-AFB
Damper crank arm Slot width 8.2 mm, clamping range Ø14...25 mm	KH10
Damper crank arm Slot width 8.2 mm, for Ø1.05"	KH12
Damper crank arm Slot width 8.2 mm, clamping range Ø10...18 mm	KH8
Push rod for KG10A ball joint (36" L, 3/8" diameter).	SH10
Push rod for KG6 & KG8 ball joints (36" L, 5/16" diameter).	SH8
TOOL-06 8mm-10mm Wrench	TOOL-06
Retrofit clip	Z-AF
Base plate extension	Z-SF
Univ. right angle bracket 17"x11-1/8"x6" (HxWxbase).	ZG-100
Univ. right angle bracket 13x11x7-7/16" (HxWxbase).	ZG-101
Right angle bracket for ZS-260.	ZG-109
Stand-off bracket for ZS-260.	ZG-110
AFB(X)/NFB(X) U bracket 5-7/8x5-1/2x2-19/32" (HxWxD).	ZG-118
Jackshaft mounting bracket.	ZG-120
Mounting kit for linkage operation for flat and side installation	ZG-AFB
Mounting kit for foot mount installation	ZG-AFB118
Damper clip for damper blade, 3.5" width.	ZG-DC1
Damper clip for damper blade, 6" width.	ZG-DC2
1" diameter jackshaft adaptor (11" L).	ZG-JSA-1
1-5/16" diameter jackshaft adaptor (12" L).	ZG-JSA-2
1.05" diameter jackshaft adaptor (12" L).	ZG-JSA-3
Weather shield 13x8x6" [330x203x152 mm] (LxWxH)	ZS-100
Base Plate, for ZS-100	ZS-101
Weather shield 16x8-3/8x4" [406x213x102 mm] (LxWxH)	ZS-150
Explosion Proof Housing 16x10x6.435" [406x254x164 mm] (LxWxH), UL and CSA, Class I, Zone 1&2, Groups B, C, D, (NEMA 7), Class III, Hazardous (classified) Locations, outdoor application NEMA 4	ZS-260
Weather shield 17-1/4x8-3/4x5-1/2" [438x222x140 mm] (LxWxH), NEMA 4X, with mounting brackets	ZS-300
Weather shield 17-1/4x8-3/4x5-1/2" [438x222x140 mm] (LxWxH), NEMA 4X, with mounting brackets	ZS-300-5
Shaft extension 1/2"	ZS-300-C1
Shaft extension 3/4"	ZS-300-C2
Shaft extension 1"	ZS-300-C3

Electrical installation

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Meets cULus requirements without the need of an electrical ground connection.

A Actuators with appliance cables are numbered.

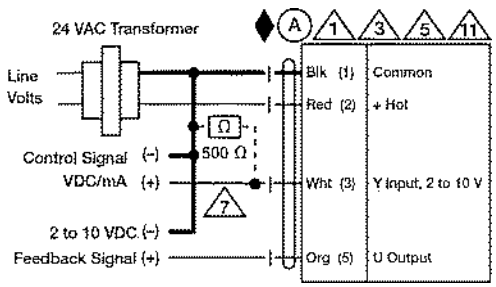
1 Provide overload protection and disconnect as required.

3 Actuators may also be powered by 24 VDC.

5 Only connect common to negative (-) leg of control circuits.

7 A 500 Ω resistor (ZG-R01) converts the 4...20 mA control signal to 2...10 V.

11 Actuators may be connected in parallel if not mechanically linked. Power consumption and input impedance must be observed.



2...10 V / 4...20 mA Control

Dimensions

Dimensional drawings