# Design Guide Checklist

<table>
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<th>Section</th>
<th>Description</th>
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<th>Comments</th>
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Please provide comments for any items that are checked No or N/A

Signature: ________________________________
*The objective of the analysis in this Excel workbook is to determine whether a vapor barrier is needed and the proper location of it, with respect to the interior or exterior side of the insulation. The goal is to avoid the dewpoint temperature dropping below the dry bulb temperature, thus causing condensation in the wall cavity, during either maximum outdoor humidity conditions in the summer or minimum outdoor humidity conditions in the winter. Unfortunately, you can only pick one location for a vapor barrier, which allows for protection against some weather conditions but failure during others. Therefore, the objective is to design around the weather conditions most likely to occur over time for a particular location, to maximize successful application of the vapor barrier and minimize failure.*

<table>
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<tr>
<th>Worksheet</th>
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Wall Option 1, No Vapor Barrier (Winter)

Dewpoint Analysis Workbook
UAF Residence Hall
TME Job No. 04-05-0029
Fayetteville, AR

Indoor Conditions:

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<tr>
<th>Points</th>
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<th>Dry Bulb Temp (Deg F)</th>
<th>Dewpoint Temp (Deg F)</th>
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<tr>
<td></td>
<td>0.000</td>
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<td></td>
<td>14.750</td>
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Relative Humidity (%) 20
Specific Humidity (grains/lb) #NAME?
Dewpoint Temperature (°F) #NAME?
Vapor Pressure (in. Hg) #NAME?

Outdoor Conditions:

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<td></td>
<td>14.750</td>
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Dry Bulb Air Temperature (°F) 16
Wet Bulb Air Temperature (°F) 13
Relative Humidity (%) #NAME?
Specific Humidity (grains/lb) #NAME?
Dewpoint Temperature (°F) #NAME?
Vapor Pressure (in. Hg) #NAME?

Specific Wall Construction:

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<tr>
<th>Material</th>
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<th>R Value (in. °F BTU)/(h*ft²°F)</th>
<th>Rep Temperature Drop (°F)</th>
<th>Vapor Pressure Drop (in. Hg)</th>
<th>Surface Temperature (°F)</th>
<th>Surface Vapor Pressure (lb H2O/lb D.A.)</th>
<th>W (in. °F BTU)/(h*ft²°F)</th>
<th>Surface Dewpoint (°F)</th>
<th>X (in)</th>
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Wall Option 1, No Vapor Barrier (Summer)

Dewpoint Analysis Workbook
UAF Residence Hall
TME Job No. 04-05-0029
Fayetteville, AR

Indoor Conditions:

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<tr>
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Specific Humidity (grains/lb):

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<th>Dewpoint Temp (Deg F)</th>
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<td>Specific Humidity (grains/lb)</td>
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<td>Vapor Pressure (in. Hg)</td>
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Dewpoint Temperature (°F):

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Dewpoint Temperature (°F):

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<th>Vapor Pressure Drop (in. Hg)</th>
<th>Surface Temperature (°F)</th>
<th>Surface Vapor Pressure (in. Hg)</th>
<th>W (lb H2O lb D.A.)</th>
<th>Surface Dewpoint (°F)</th>
<th>X (in)</th>
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Wall Option 1, No Vapor Barrier (Summer)
## Wall Option 2, No Vapor Barrier (Winter)

**Dewpoint Analysis Workbook**  
**UAF Residence Hall**  
**TME Job No. 04-05-0029**  
**Fayetteville, AR**

### Indoor Conditions:

<table>
<thead>
<tr>
<th>Points</th>
<th>Dry Bulb Temp (Deg F)</th>
<th>Dewpoint Temp (Deg F)</th>
<th>Relative Humidity (%)</th>
<th>Specific Humidity (grains/lb)</th>
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<tbody>
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<td>68</td>
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### Outdoor Conditions:

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<th>Wet Bulb Temp (Deg F)</th>
<th>Specific Humidity (grains/lb)</th>
<th>Dewpoint Temp (Deg F)</th>
<th>Vapor Pressure (in. Hg)</th>
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### Typical Wall Construction:

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<th>Thickness (in.)</th>
<th>R Value (hr*ft²°F/ BTU)</th>
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<th>Vapor Pressure Drop (in. Hg)</th>
<th>Surface Temperature (°F)</th>
<th>Surface Vapor Pressure (in. Hg)</th>
<th>Surface Dewpoint (°F)</th>
<th>X (in.)</th>
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<tbody>
<tr>
<td>Interior Air Film</td>
<td>0.000</td>
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### Wall Option 2: No Vapor Barrier (Winter)

- **Dry Bulb Temp (Deg F)**
- **Dewpoint Temp (Deg F)**

![Graph of Wall Option 2, No Vapor Barrier (Winter)](image-url)
Wall Option 2, No Vapor Barrier (Summer)

Dewpoint Analysis Workbook
UAF Residence Hall
TME Job No. 04-05-0029
Fayetteville, AR

Indoor Conditions:

<table>
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<tr>
<th>Points</th>
<th>Dewpoint Temp (Deg F)</th>
<th>Dry Bulb Temp (Deg F)</th>
<th>Relative Humidity (%)</th>
<th>Specific Humidity (grains/lb)</th>
<th>Vapor Pressure (in. Hg)</th>
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Outdoor Conditions:

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<th>Relative Humidity (%)</th>
<th>Specific Humidity (grains/lb)</th>
<th>Vapor Pressure (in. Hg)</th>
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Typical Wall Construction:

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<tr>
<th>Surface</th>
<th>Thickness (in.)</th>
<th>R Value (h-ft²-°F)/BTU</th>
<th>Temperature Drop (°F)</th>
<th>Vapor Pressure Drop (in. Hg)</th>
<th>Surface Vapor Pressure (in. Hg)</th>
<th>Surface Temperature (°F)</th>
<th>H (lbf ft² lb D.A.)</th>
<th>Surface Dewpoint (°F)</th>
<th>X (in.)</th>
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Totals: 11.2500 26.55 3.3398 -22.0 #NAME?
<table>
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<tr>
<th>Property</th>
<th>Address</th>
<th>Room</th>
<th>Area (sq ft)</th>
<th>Ceiling Height (ft)</th>
<th>Room Type</th>
<th>Exposed Exposure</th>
<th>Elevator Zone</th>
<th>Exit Zone</th>
<th>Total Zone</th>
<th>Zone Min Fall</th>
<th>Zone Min Travel</th>
<th>Avg. Time to Evac.</th>
<th>Design Flow</th>
<th>Exhaust Flow</th>
<th>Total Flow</th>
<th>Exhaust Rate</th>
<th>Exhaust百分比</th>
<th>Exhaust Source</th>
<th>Exhaust Source Type</th>
<th>Exhaust Source Location</th>
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<td>ABC Hotel</td>
<td>123 Main St</td>
<td>Room 1</td>
<td>500</td>
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<td>Office</td>
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<td>Zone 1</td>
<td>Zone 2</td>
<td>Zone 3</td>
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<td>30</td>
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<td>70%</td>
<td>Exhaust Stack</td>
<td>Lobby</td>
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<td>1000</td>
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<td>Zone 5</td>
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<td>80%</td>
<td>Exhaust Duct</td>
<td>Meeting Room</td>
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**Total Exits:**

- Total Flow: 500
- Exhaust Rate: 70%
- Exhaust Source: Lobby
- Exhaust Source Type: Stack
- Exhaust Source Location: 1st Floor
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<th>ASHRAE 62.1-2004 ed Space type</th>
<th>Occupant Density (#/100ft²)</th>
<th>Rp (cfm/per)</th>
<th>Ra (cfm/ft²)</th>
<th>Exhaust Rate CFM/fixture</th>
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<td>Darkrooms</td>
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<td>Kitchen - Commercial</td>
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<td>Kitchens</td>
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<td>Locker Rooms</td>
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<td>Locker/dressing rooms</td>
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<td>Parking garages</td>
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<td>Janitor , trash, recycle</td>
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<td>Science lab classrooms</td>
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<td>Toilets - public</td>
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<td>Toilets - private</td>
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<td>Woodwork shop/classroom</td>
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</tr>
</tbody>
</table>
1.0 Electrical Load Calculations:

1.01 General: The electrical system designer shall calculate the estimated peak building demand for electricity. The calculated peak demand shall consider load diversity. The calculations shall identify the peak electrical demand associated with each energy system including air handling systems, heating water system, chilled water system, domestic hot water system, elevators, exhaust fans, interior lighting, exterior lighting, and miscellaneous equipment\(^1\). The electrical system designer shall also determine the appropriate capacity of the building primary transformer.

1.02 Sample Electrical Load Calculations: Refer to Appendix D for sample building electrical load calculations.

### Daily allowable peak loads for transformer normal life expectancy at 30 degree C ambient

<table>
<thead>
<tr>
<th>Peak load duration hours</th>
<th>Mineral-oil, self-cooled (65 C Rise)</th>
<th>Dry-type, self-cooled, (150 C Rise)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Allowable peak load in percent of rated capacity following and followed by the indicated percent constant load(^a)</td>
<td>Allowable peak load in percent of rated capacity following and followed by the indicated percent constant load(^a)</td>
</tr>
<tr>
<td></td>
<td>50%</td>
<td>70%</td>
</tr>
<tr>
<td>1/2</td>
<td>200</td>
<td>199</td>
</tr>
<tr>
<td>1</td>
<td>183</td>
<td>172</td>
</tr>
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<td>2</td>
<td>157</td>
<td>150</td>
</tr>
<tr>
<td>4</td>
<td>134</td>
<td>130</td>
</tr>
<tr>
<td>8</td>
<td>118</td>
<td>116</td>
</tr>
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</table>

\(^{a}\)Facsimile for reference only of Table 8.2 of Army Technical Manual “TM 5-811-1/AFJMAN”

\(^1\) Computers, printers, copiers, task lighting, etc.
APPENDIX D

SAMPLE BUILDING
SERVICE SIZING CALCULATIONS SUMMARY

DATE
Job # _ _ _

CONNECTED LOAD: 3044.5kVA
PEAK LOAD: 2558kVA
SERVICE TRANSFORMER SIZE: 2000kVA

<table>
<thead>
<tr>
<th>Panel</th>
<th>Column A</th>
<th>Column B</th>
<th>Column C</th>
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</thead>
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<tr>
<td>GNH1</td>
<td>51</td>
<td>40.1</td>
<td></td>
</tr>
<tr>
<td>INH1</td>
<td>106.2</td>
<td>73.1</td>
<td></td>
</tr>
<tr>
<td>2NH1</td>
<td>90.1</td>
<td>75.5</td>
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<tr>
<td>3NH1</td>
<td>208.8</td>
<td>101.8</td>
<td>76.3</td>
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<tr>
<td>QHD</td>
<td>844</td>
<td>1.1</td>
<td>671.5</td>
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<tr>
<td>CDP</td>
<td>203.4</td>
<td>143</td>
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<tr>
<td>SDP</td>
<td>81.2</td>
<td>81.2</td>
<td></td>
</tr>
<tr>
<td>NHD TOTAL</td>
<td>1584.7</td>
<td>515.8</td>
<td>747.8</td>
</tr>
<tr>
<td>GHM1</td>
<td>628.5</td>
<td>534.2</td>
<td></td>
</tr>
<tr>
<td>GHM2</td>
<td>831.3</td>
<td>706.6</td>
<td></td>
</tr>
<tr>
<td>NDP TOTAL</td>
<td>3044.5</td>
<td>515.8</td>
<td>1988.7</td>
</tr>
</tbody>
</table>

**CONNECTED KVA:** 3044.5kVA (3662A)
Connected kVA at 3044.5kVA is a straight addition of the loads in the panel schedules. No demand allowances are taken of any kind.

**DEMAND KVA:** 2558.4kVA (3077A)
Rationalization for sizing the service transformer at 2000kVAv: Mineral oil self-cooled 65°C rise

**JOB SPECIFIC ASSUMPTIONS:** All are estimates unless (noted) otherwise
**COLUMN A:** Lights are taken at 100% of connected load

Receptacles are taken at code, first 10,000VA plus 50% of that above(NEC)

Mechanical equipment with no VFD taken at 100% of connected kVA

**COLUMN B:** All mechanical equipment with VFD taken at 85% of connected kVA

**COLUMN C:** One elevator taken at 100% refers to 25% duty cycle of four elevators
Building peak demand lasts 4 hours, and then falls back to 70% of peak: From table of 1.02 find factor of 1.30, therefore 2558.4 + 1.30 = 1968kVA, so use next larger size 2000kVA.
REQUEST FOR BIDS

COOLING TOWER

University of Arkansas
Fayetteville, Arkansas

March 6, 2002

TME Project No. 01-166
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<td>Package “A” Bid Form</td>
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<td>Package “B” Bid Form</td>
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<td>Verification of Performance Specifications</td>
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<td>Extended Warranty Specifications</td>
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<td>00800</td>
<td>Disclosure Form</td>
<td>3</td>
</tr>
<tr>
<td>00900</td>
<td>Drawings</td>
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</tr>
</tbody>
</table>
1. The University of Arkansas (Owner) is soliciting bids from equipment suppliers ("Suppliers") to furnish a three cell cooling tower for the University of Arkansas Southwest Central Plant

2. Sealed bids will be received at the University of Arkansas, Office of Business Affairs, Administration Building Room 321, Fayetteville, Arkansas 72701 until 2:00 P.M., April 3, 2002.

3. Bids will be received and evaluated privately. Suppliers submitting bids will be notified of selection within thirty (30) calendar days after designated closing time for the receipt of bids.

4. Copies of the bid documents may be obtained at the Office of Business Affairs and offices of TME Consulting Engineers, 5800 Evergreen Drive Suite A; Little Rock, Arkansas 72205.

5. Bids may not be withdrawn for a period of ten (10) days after the designated closing time for the receipt of bids.

6. The Owner reserves the right to reject any or all bids and to waive any formality or irregularity in any bid.
1. **Selection Criteria:** Bids will be evaluated based upon physical size, equipment cost, estimated installation costs, estimated energy costs, estimated maintenance costs, and other factors. Vendor bids shall be based on the lowest horsepower design. Selection will be based on the lowest cost bid meeting the specifications. Owner will select either Package A or Package B.

2. **Southwest Central Plant:** The chillers will be installed in the new Southwest Central Plant at the University of Arkansas. The Architect for the project is Browning Day Mullins Deirdorf Architects. The Engineer for the project is TME Consulting Engineers. The General Contractor for the project will be selected by competitive bid process.

3. **Purchasing, Receiving and Installation Instructions for Cooling Tower:** The University of Arkansas will purchase the Cooling Tower, as described below, from the selected Cooling Tower Supplier. The Cooling Tower supplier will be required to breakout (on the bid form) the cost of material, engineering, shop drawings, warranty and start up separately from his labor cost to install the cooling tower components of the cooling tower. The Southwest Central Plant Contractor will be selected using a competitive bidding process. The Contract Documents for the Southwest Central Plant project will instruct the Contractor to include the installation cost for the pre-selected cooling tower in his bid. The contractor will construct the cooling tower enclosure in accordance with the Southwest Central Plant construction documents and the Supplier’s suggested enclosure recommendations. The selected Supplier must install the cooling tower in the precast concrete structure erected by the Southwest Central Plant Contractor. The tower supplier will be required to contract with and install the cooling tower under the construction contract for the Southwest Center Plant Project. The Tower Supplier will be required to provide equipment, submittal documents (shop drawings and maintenance manuals), coordinate cooling tower equipment delivery, unload the cooling tower equipment, and install the cooling tower equipment.

4. **Bids:** Suppliers may submit one or more Bids based on possible different configurations of the cooling tower. However, the basic shape and arrangement of the cooling tower enclosure will be based on the attached drawings. The Owner may select the Bid considered to be in the best interest of the Owner based on the requirements in item 1 above.

5. **Laws and Regulations:** The selection and procurement of the equipment is subject to all applicable State laws, municipal ordinances, and rules and regulations of authorities having jurisdiction. Bids shall be structured to comply with these requirements.

6. **Form:** Bids shall be made on the form included in the Request for Bids. Bids shall be submitted in a sealed envelope. Each envelope shall be clearly marked to indicate the name of the Supplier.

7. **Content:** Each Bid shall contain as a minimum the following information:
   
   A. Physical description of the proposed equipment (refer to Section 00500 for additional information).
B. Performance data for the cooling tower at each set of defined operating conditions (refer to Section 00500 for additional information).

C. A complete list of references where equipment of similar configuration and capacity has been installed (refer to Section 00500 for additional information).

D. A completed Disclosure Form (refer to Section 00800).

E. Preliminary shop drawings on physical descriptions and arrangement of cooling tower enclosure and basin. Shop drawings shall include bid changes to the attached preliminary drawings of the tower basin and shell.

F. A completed Bid Form.

8. **Existing Conditions:** Before submitting a Bid, Supplier shall thoroughly examine the Bid Documents. Suppliers shall fully inform themselves of all conditions and requirements and shall include in their Bids an amount that is sufficient to cover all such items. Suppliers shall also fully inform themselves as to the site conditions where the tower will be erected.

9. **Delivery of Bids:** Bids shall be delivered by the time and to the place stipulated in the Request for Bids. It is the sole responsibility of the Supplier to ensure that the Bid or Bids are received in proper time. Any Bid received after the scheduled closing time for receipt of bids shall be returned to the Supplier unopened.

10. **Withdrawal:** Any Supplier may withdraw their Bid, either personally or by written request, at any time prior to the scheduled closing time for receipt of Bids.

11. **Interpretation of Documents:** If any person contemplating submitting a Bid is in doubt as to the true meaning of any part of the Request for Bids, or finds discrepancies or omissions, he may submit to the Owner’s representative, TME Consulting Engineers, a written request for an interpretation or correction thereof. The person submitting the request will be responsible for its prompt delivery. Any interpretation or correction of the documents will be made only by Addendum duly issued and a copy of the Addendum will be mailed or delivered to each person receiving a Request for Bids. The Owner will not be responsible for any other explanations or interpretations of the Request for Bids.

12. **Addenda:** Any Addenda issued during the time of submission of Bids, shall be covered in the Bid and shall be made a part of the Contract. The supplier on the Bid Form in the location provided shall acknowledge receipt of each Addendum.

13. **Delivery:** It is anticipated that the successful Supplier will receive a Letter of Intent to purchase the selected equipment by not later than April 10, 2002. The submittal documents for the equipment shall be submitted by the Supplier to the Contractor for processing and approval by not later than fourteen (14) calendar days after the receipt of the Letter of Intent. The Supplier shall be prepared and capable of making delivery to the project site no later than July 02, 2002. The time and date of delivery of the equipment shall be coordinated between the Supplier and the Southwest Central Plant Contractor. Failure by the Supplier to make delivery within the specified time frame (if required by the Contractor) shall result in the assessment of liquidated damages in the amount of $200 per calendar day. The Supplier shall pay these damages directly to the Owner.

14. **Sales Tax:** Bids shall include applicable sales tax.
15. **Project Acceptance for the Southwest Central Plant Project:** The date of Project Acceptance for the Southwest Central Plant Project shall be the date on which the Engineer (TME) and the Owner accept the project and approve the payment final retainage to the General Contractor.

16. **Payment Terms for Equipment:** The Supplier shall receive payment for the Equipment (including the first year warranty) from the University of Arkansas. The Supplier shall receive a payment in the amount of the contract amount within sixty (60) calendar days after the delivery of the equipment.

17. **Payment Terms for Extended Warranty:** The Supplier shall receive payment for the Extended Warranty from the University of Arkansas (if this Alternate is accepted by the Owner). The Supplier shall receive payment in the amount of the contract amount within sixty (60) calendar days after the delivery of the equipment.

18. **Price Escalation and Carrying Charges:** The amounts indicated on the Bid Form for Equipment and Extended Warranty shall be inclusive of all required price escalation and carrying charges associated with the timing of the equipment purchase and the specified partial payments. Payments for these items will be made at the stipulated amount. No adjustments for price escalation and / or carrying charges will be made.

19. **Bid Acceptance:** Pricing for Equipment and Extended Warranty shall be valid until the dates indicated for the receipt of a purchase order. The Owner may elect to accept the Equipment Bid and reject the Extended Warranty Bid. It is understood that the Supplier’s pricing for the Extended Warranty Bid is conditional upon the Owner’s acceptance of the Supplier’s Associated Equipment Bid.

20. **Failure to Receive a Purchase Order:** In the event that the selected Supplier fails to receive a Purchase Order for the equipment prior to the date indicated above, the selected Supplier and the Owner shall be unconditionally released of all obligations. The Supplier and the Owner, however, may decide to proceed with the purchase based upon revised terms and conditions that are agreeable to both parties.

21. **Termination of the Equipment Purchase by the Owner for Convenience:** The Owner may elect to terminate the purchase of the equipment for convenience and without cause at any time. Upon receipt of written notice from either the Owner or the Contractor of such termination, the Supplier shall immediately terminate all Purchase Orders and enter into no further Purchase Orders. If such termination for convenience occurs after the receipt of a Purchase Order by the Supplier from the Contractor, the Supplier shall be entitled to recover payment for proven loss associated with respect to submittal preparation, materials, labor, tools, and equipment including reasonable overhead, profit, and damages. If such termination for convenience occurs prior to the receipt of a Purchase Order, the Supplier shall not be entitled to recover payment for any type of loss or damage.

22. **Termination of the Equipment Purchase by the Owner for Cause:** The Owner may elect to terminate the purchase of the equipment for cause if the Supplier either (1) disregards laws, ordinances, or rules, regulations or orders of a public authority having jurisdiction or (2) is otherwise guilty of a substantial
breach of a provision of the Bid Documents. If the purchase is terminated by the Owner for cause, the Owner shall be entitled to recover payment from the Supplier for proven loss.

23. **Shop Drawings, Submittal Documents, and Maintenance Manuals:** The selected Supplier shall furnish to the Contractor eight (8) copies of shop drawings, submittal documents, and maintenance manuals (refer to Section 00500 – Equipment Specifications for Additional information.

24. **Ownership and Responsibility:** The Supplier shall be responsible for all arrangements and costs associated with equipment including freight, insurance, and taxes until delivery to the project site and signed acceptance by the Contractor’s representative. Place of delivery shall be the University of Arkansas, Southwest Chiller Plant; Fayetteville, Arkansas 72205. Equipment title shall pass to the Owner at Project Acceptance. Supplier shall notify the Contractor and the Owner’s project manager forty-eight (48) hours prior to delivery.
Bid of ____________________________
(Hereinafter called “Supplier”), corporation, organized and existing under the laws of the state of ____________________________ partnership, or and individual doing business as ____________________________.

To: Office of Business Affairs
University of Arkansas
Administration Building, Room 321
Fayetteville, AR 72701

Gentlemen:

The Supplier, in compliance with your Request for Bids to purchase equipment for the University of Arkansas, having examined the Bid Documents and being familiar with all conditions of these documents, hereby proposes to furnish equipment in accordance with the Bid Documents, within the time set forth therein, and at the prices stated below.

Supplier acknowledges receipt of the following Addenda:

________________________________________________________________________

Equipment Bid:

Supplier agrees to furnish the cooling tower (including all engineering, shop drawings, material, and start-up assistance and the first year warranty) as described in the Package “A” Bid Documents for the total sum of:

________________________________________________________________________

Dollars ($ ____________________ )

Labor Bid

Supplier agrees to install the cooling tower as a part of the Southwest Central Plant construction contract as described in the Package “A” Bid Documents for the total sum of:

________________________________________________________________________

Dollars ($ ____________________ )
Verification of Performance Bid:

Supplier agrees to provide Verification of Performance for the cooling tower as described in the Bid Documents for the total sum of:

________________________________________________________________________

________________________________________________________________________ Dollars ($______________________)

Extended Warranty Bid:

Supplier agrees to furnish the Extended Warranty for the cooling tower as described in the Bid Documents for the total sum of:

________________________________________________________________________

________________________________________________________________________ Dollars ($______________________)

Supplier understands that the Owner reserves the right to reject any or all Bids and to waive any formalities in the Bids.

(Seal if by corporation) Respectfully submitted,

________________________________________________________________________

Business Address Supplier

Date:________________________, 2002 By:________________________

Title:________________________
Bid of ____________________________________________________________
(Hereinafter called “Supplier”) corporation, organized and existing under the laws of the
state of ________________________________ partnership, or and individual doing
business as ______________________________.

To: Office of Business Affairs
   University of Arkansas
   Administration Building, Room 321
   Fayetteville, AR  72701

Gentlemen:

The Supplier, in compliance with your Request for Bids to purchase equipment for the
University of Arkansas, having examined the Bid Documents and being familiar with all
conditions of these documents, hereby proposes to furnish equipment in accordance with
the Bid Documents, within the time set forth therein, and at the prices stated below.

Supplier acknowledges receipt of the following Addenda:

______________________________________________________________

Equipment Bid:

Supplier agrees to furnish the cooling tower (including all engineering, shop drawings,
material, and start-up assistance and the first year warranty) as described in the Package
“B” Bid Documents for the total sum of:

________________________________________________________________

________________________________________________________________

Dollars ($___________ )

Labor Bid

Supplier agrees to install the cooling tower as a part of the Southwest Central Plant
construction contract as described in the Package “B” Bid Documents for the total sum of:

________________________________________________________________

________________________________________________________________

Dollars ($___________ )
Verification of Performance Bid:
Supplier agrees to provide Verification of Performance for the cooling tower as described in the Bid Documents for the total sum of:

$______________________________

______________________________ Dollars ($______________________________)

Extended Warranty Bid:
Supplier agrees to furnish the Extended Warranty for the cooling tower as described in the Bid Documents for the total sum of:

$______________________________

______________________________ Dollars ($______________________________)

Supplier understands that the Owner reserves the right to reject any or all Bids and to waive any formalities in the Bids.

(Seal if by corporation) Respectfully submitted,

______________________________
Business Address Supplier

Date:__________________________, 2002 By:______________________________

Title:______________________________
Design Conditions:

The cooling tower shall be selected to operate at the conditions listed below:

1. Capacity: 3000 total Tons
2. Entering Water Temperature - 95°F
3. Leaving Water Temperature - 85°F
4. Ambient Wet Bulb Temperature - 79°F
5. Total Water Flow - 9,000 gpm
6. Electrical Service - 480 volts / 3 phase
7. Sound Requirements - 60 dbA at 100 feet

Water flow shall be equally divided between numbers of cells required to meet the design capacity.
Design Conditions:
The cooling tower shall be selected to operate at the conditions listed below:

1. Capacity: 3000 total Tons
2. Entering Water Temperature - 97°F
3. Leaving Water Temperature - 85°F
4. Ambient Wet Bulb Temperature - 79°F
5. Total Water Flow - 7,500 gpm
6. Electrical Service - 480 volts / 3 phase
7. Sound Requirements - 60 dbA at 100 feet

Water flow shall be equally divided between numbers of cells required to meet the design capacity.
PART 1 - GENERAL

1.01 SCOPE OF WORK:
   A. The Cooling Tower Manufacturer shall be responsible for the design, fabrication, and delivery of materials to the project site, and for the installation of the tower components.
   B. The Cooling Tower Manufacturer shall be responsible for furnishing structure sizes, weight loading information and support features required for proper design of the basin, shell and fan deck.
   C. The concrete structure, basin and foundation will be designed by the Engineer and installed by the Contractor based upon certified loading and dimensional data provided by the Cooling Tower Manufacturer.
   D. The Contractor shall furnish and install all supply and return piping, risers, valves, pumps, sumps and screens anchor bolts, controls, electrical wiring, lightning protection, and water treatment equipment.

1.02 QUALITY ASSURANCE:
   A. Experience: At the time of submission of the bid, the cooling tower model must have been in standard production for a minimum of one year.
   B. CTI (Cooling Tower Institute) Standards: Provide cooling towers which meet the performance standards of CTI Standards STD-201.
   C. NEMA (National Electric Manufacturers Association) and IEEE Compliance: Provide electric motors which meet the scheduled full load efficiency, per NEMA Standard MGI-12.53a, based on dynamometers testing per IEE 12 Method B.
   E. NEMA and UL (Underwriters Laboratories) Compliance: Provide electric motors and products which have been listed and labeled by UL and comply with NEMA standards.

1.03 DELIVERY, STORAGE AND HANDLING: Coordinate delivery, storage, and handling with the Contractor. Refer to Section 00200 - General Conditions.

1.04 PERFORMANCE DATA: Performance data for the design operating conditions (refer to Section 00400 – Package “A” Equipment Performance Data and Section 00410 – Package “B” Equipment Performance Data) shall be provided with each bid. Performance data shall include flow rate, entering water temperature, leaving water temperature, pressure drop, sound pressure level (dBA), motor voltage and motor current (RLA).
1.05 PHYSICAL DESCRIPTION: A physical description of each cooling tower shall be provided with each Bid. The physical description shall include the following information:

A. Detailed drawings of the proposed equipment including a top view, right side view, and end view. The drawings shall indicate the dimension of the cells, locations of all connections (tower water, electrical controls, drain, overflow, make-up water, etc.), and service clearances. The drawings shall also indicate the type and size of each piping connection.

B. The tower manufacturer’s shop drawings shall be site specific for this project. The intent of the tower manufacturer’s shop drawings is not to design the tower shell or basin. However, the shop drawings shall indicate the following as a minimum:

1. Tower basin internal dimensions, including all support points, lateral and vertical forces for tower materials.
2. Tower shell internal dimensions, including all support points lateral and vertical forces for tower materials.
3. Flume way minimum water volume requirements for a dry basin tower design.
4. All tower materials furnished and installed by the tower manufacturer.

C. Detailed electrical wiring diagram that indicates all required field wiring and components including power and controls.

D. Detailed shipping instructions including shipping weights, operating weights, and rigging instructions.

E. Detailed installation instructions that address all installation requirements including rigging piping, anchors, mounting of sensors, etc.

F. Product data indicating motor speed (RPM), type of motor, type of bearings, fan description, fill material, and tower shell material.

G. Other information required to verify compliance with the Bid Documents.

1.06 REFERENCES: A complete list of references for each type of cooling tower shall be provided with each bid. The list shall include a minimum of five (5) references. The list shall indicate the name of the facility where the equipment has been installed, location (city and state) of the equipment, installation date, equipment capacity (tons), contact name, and contact telephone number for each reference.

1.07 FIRST YEAR WARRANTY: Provide a complete equipment warranty on all parts and material for one (1) year after the applicable date of Project Acceptance. The cost of the first year warranty shall be included in the amount indicated for the line item designated “Equipment Bid” on the Bid Form.

1.10 INSTALLATION AND START-UP ASSISTANCE: Supplier shall provide installation and start-up assistance to the Contractor. Such assistance shall be provided by a factory trained and certified technician. The date of the installation and start-up assistance provided by the Supplier shall be coordinated with the Contractor and the Owner. Service representative shall inspect the equipment installation and verify that the installation is in accordance with factory
recommendations. Service representative shall verify that the power wiring, control wiring, piping connections, flow rates, and temperatures are correct prior to starting the equipment. The service representative shall thoroughly document the conditions at start-up in a detailed report. The service representative shall submit eight (8) copies of the report to the Contractor for processing and review by the Architect, Engineer, and Owner. The cost of the installation and start-up assistance shall be included in the amount indicated for the line item designated “Equipment Bid” on the Bid Form.

1.11 VERIFICATION OF PERFORMANCE BID: Supplier shall provide a bid to provide verification of equipment performance (refer to Section 00600 – Verification of Performance Specifications for additional information). The cost of the verification process shall be indicated on the Bid Form on the line item designated “Verification of Equipment Performance Data Bid”.

1.12 EXTENDED WARRANTY BID: Supplier shall provide a bid to provide a four (4) year extension of the first year equipment warranty (refer to Section 00700 – Extended Warranty Specifications for additional information). The cost of the four (4) year warranty extension shall be indicated on the Bid Form on the line item designated “Extended Warranty Bid”.

1.13 SUBMITTALS: After receipt of a Letter of Intent or Purchase Order, the Supplier shall submit eight (8) copies of submittal documents to the Contractor. Each set of submittal documents shall be bound together in 3-ring binder. The binder shall be clearly marked to indicate the name of the project, Owner, Contractor, Architect, Engineer, and Supplier. The information shall be organized into sections. Each section shall be tabbed and labeled. Each set of submittal documents shall include the information listed below:

A. Physical Description: Refer to Paragraph 1.05 above for required information.

B. Performance Data: Refer to Paragraph 1.04 for required information.

C. Operation and Maintenance Manuals: Manuals shall include operating instructions, maintenance instructions, troubleshooting information, parts lists, and other related information.

PART 2- PRODUCTS

2.01 INDUCED DRAFT COUNTER FLOW TOWER:

A. Furnish and install an induced draft, counterflow – type, field erected, film – fill, industrial – duty, concrete cooling tower of three (3) cells. The limiting dimensions of the tower shall be approximately 20’ – 0” inside width x 74’ – 0” inside length (with two 12” wide septum walls) x 30’ – 0” high (top of the fan cylinders). Total operating horsepower of the fans shall not exceed 150 HP. The tower constructed of materials intended to upgrade without the need for a fire-protection sprinkler system.

B. Design Loading: The tower shall be designed to withstand a wind load of 30 psf, or a Zone 2 seismic load, per current UBC Code. Fan decks and other work levels shall be designed for a uniform load of 60 psf, or a concentrated live load of 600 lbs. Allowable deflection at 60 psf uniform load shall be 1/180 of span. Fill and fill supports shall be capable of withstanding a 60-psf live load. Guardrails shall be capable of withstanding
100 lbs. per lineal foot vertical live load, or a 200 lb. concentrated live load in any direction.

C. Basin (To be furnished by the Contractor):

1. The basin floor slab shall be a continuous pour of high-density air-entrained concrete throughout the tower structure. All concrete shall provide nominal 2" cover over reinforcing steel per ACI 318, and shall be designed for a minimum 4000 psi compressive strength at 28 days. Reinforcing bars shall be deformed and shall comply with ASTM A615 Grade 60. All concrete shall use Type II Portland Cement and shall be air entrained. Cement mix density shall be 658 lb/cubic yard of concrete. The use of fly ash or curing agents shall be as approved by the Owner.

2. All exposed concrete shall be rub-finished to provide a smooth and uniform surface free of form marks and defects. Honeycomb concrete will not be permitted.

3. A continuous stripping of molded polyvinyl plastic water-stop (6 inch dumbbell or equal) shall be located on the centerline position of the basin wall section/basin floor slab intersection, and at all other cold pour joints.

4. The basin wall sections shall be made in a second continuous pour, and shall contain the necessary reinforcing steel as called for on the architectural or engineering drawings and shall be so arranged as to interlock with the water-stop seal in the floor slab to form a completely waterproof basin.

5. Any cold pour joints in vertical walls shall have a continuous stripping of molded polyvinyl plastic water-stop (six inch dumbbell) or equal.

D. Tower Shell (To be furnished by the Contractor):

1. The tower wall sections shall be constructed of monolithic high-density air-entrained concrete throughout the tower structure. All concrete shall provide nominal 2" cover over reinforcing steel per CI 318, and shall be designed for a minimum 4000 psi compressive strength at 28 days. Reinforcing bars shall be deformed and shall comply with ASTM A615 Grade 60. All concrete shall use Type II Portland Cement and shall be air entrained. Cement mix density shall be 658 lb/cubic yard of concrete. The use of fly ash or curing agents shall be as approved by the Engineer.

2. All internal exposed concrete shall be rub-finished to proved a smooth and uniform surface free of form marks and defects. Honeycomb concrete will not be permitted. Exterior surfaces shall match adjacent building precast concrete panels.

3. Structural framing connections shall be bolted 304L stainless steel plates, clips, and bolts. Bidders shall include with their quotation complete column base load tables for all specified loading conditions. Transverse and longitudinal column spacing shall not exceed 30 feet on centers.
4. If precast, the concrete casing shall be bolted to the columns. The casing shall provide support for internal structure and components, and shall stiffen the structure for wind and seismic loads. Structural casing hardware shall be Type 304L stainless steel plates, clips, and bolts.

5. Structural support beams may be precast. Precast shall rest on neoprene bearing pads to avoid abrasion and localized stresses. Pre-stressed members shall not be used in the wetted area of the tower. Where pre-stressed members are used, tendon anchorage protection shall be provided. Torch-cutting of pre-stressed tendons at the concrete face will not be allowed.

6. The fan deck shall act as a working platform for operation and maintenance personnel. Fan deck shall have a broom finish for skid resistance.

E. Mechanical Equipment:

1. The primary air delivery system for each cell shall consist of an electric motor, an extended drive shaft, a geared speed-reduction unit, a multi-bladed propeller-type fan, and a rigid support.

2. Motors shall be single-speed, single winding, variable torque, 50 hp maximum, TEFC, and specially insulated for cooling tower duty. Speed and electrical characteristics shall be 1800 RPM, 3 phase, 60 hertz, 460 volts with a 1.15 service factor. The service factor beyond 1.0 shall not be considered available for load.
   a. Furnish and install premium efficiency motors. Motors shall comply with NEMA MG1 part 31.40.4.2 limiting 0.1 micro second rise from 10% to 90% of steady state voltage with a 1600 volt maximum peak.
   b. All equipment specified with premium efficiency motors shall include data sheets, with equipment submittals, on motors. Data sheets shall include manufacturer/model number of motor including statement motor complies with NEMA standard MG1 part 31.40.4.2.

3. Motors shall be located outside the fan cylinders and shall be connected to the speed reducers by tubular, extended, full floating, non-lubricated drive shafts. Drive shaft tubes and flanges shall be manufactured of type 304 stainless steel. Couplings shall be cast 304 stainless, joined to the drive shaft by flexible neoprene bushings and type 302 stainless steel inserts. Connecting hardware shall be 300 stainless steel. Drive shaft assemblies shall be dynamically balanced at the factory at full motor speed. Two galvanized steel drive shaft guards anchored to the mechanical equipment support shall surround the drive shaft for containment in the event of failure.

4. Gear reduction units shall be right-angle type, utilizing helical and/or spiral bevel matched gear sets. Cases shall be epoxy-coated, ASTM Class 20, gray cast iron. Bearings shall be tapered roller type. Gears and bearings shall be splash-lubricated in a bath of oil, and units shall be capable of operating in either forward or reverse with
equal facility. Speed reduction units using external oil pumps will not be allowed. Gear reducers shall meet or exceed the requirements of CTI STD-111 and AGMA Std. 420.04, and service factor at applied horsepower shall not be less than 2.0., run at the vendor's factory under load to verify acceptable service. Interior surfaces of the gear reducer shall be coated with a rust-proofing oil prior to shipment.

5. Each cell shall be equipped with an external oil level gauge and gear reducer drain line, terminating at a sight-glass and plug located outside the fan cylinder near the motor. Lines and sight-glass shall be stainless steel.

6. Fans shall have FRP blades, with appropriate twist and taper to produce maximum airflow capability. Blades of fans 20 ft diameter and smaller may be hollow core. All blades shall be fabricated with consistent moment weights to permit the change-out of individual blades without the need for total fan rebalance. Hubs shall be fabricated of hot-dip galvanized steel and ductile cast iron, assembled with series 300 stainless steel hardware. Spoke-type hubs, if used, shall be equipped with an FRP hub cover to prevent re-circulation of air at the plane of the fan. Hubs shall be statically balanced at the factory.

7. A solid state, capacitance-actuated, CSA approved low oil level switch shall be provided and installed outside the fan cylinder for wiring into the owner's control panel. The switch shall be Robertshaw Level-Tek Model 318A or approved equal.

8. A single-pole, double-throw vibration limit switch in a NEMA 4 housing shall be installed on the mechanical equipment support for wiring into the owner's control panel, to interrupt power to the motor in the event of excessive vibration. Switch shall be adjustable for sensitivity, and shall require manual reset.

F. Fill and Drift Eliminators:

1. Fill shall be cellular film-type, thermo-formed PVC, manufactured of 20 mil (after forming) or heavier stock. Fill shall be assembled into packs.

2. Fill shall be supported on centers as required to accommodate operational loads, as well as the specified 60 psf live load. The support system shall not obstruct airflow through the fill. Fill shall be suspended or bottom supported.

3. Drift eliminators shall be thermo-formed of 20 mil minimum sheet thickness with 30 mil minimum PVC stiffeners, cellular type, triple-pass, and shall limit drift losses to no more than 0.001% of the design water flow rate. Drift eliminators shall form a continuous plane of drift eliminators throughout the plan area of each tower cell. Eliminators shall be supported by FRP structural shapes, and shall be elevated to clear the spray nozzles by no less than 24".

G. Fan Cylinders:
1. Fan cylinders shall be molded fire retardant FRP (25 or less flame spread rating) with eased inlets to promote smooth airflow at blade tips.

2. The operating plane of the fan shall be at a level above the fan deck of at least 15% of the overall fan diameter. Fan tip clearance shall not exceed 0.5% of the fan diameter. If velocity recovery fan cylinders are used, they shall have a maximum flare angle of 12°, with a maximum assumed velocity recovery of 75% of the difference in average velocity pressure.

3. Each fan cylinder segment shall be bolted to the fan deck. Fan cylinder connection and anchorage hardware shall be series 300 stainless steel. Fan cylinders less than 6'-0 high shall be equipped with a hot dipped galvanized fan guard.

H. Water Distribution System:

1. Hot water shall be distributed to the fill in each cell via a system of headers, laterals, branch arms, and nozzles, installed in the region above the fill and beneath the drift eliminators.

2. Headers and distribution piping shall be a minimum Schedule 40 PVC. Branch arms and nozzles shall be polypropylene or ABS.

3. The joint between branch arms and nozzles shall be threaded so nozzles can be removed for cleaning of the branch arms. Nozzles shall be large orifice, low-pressure, down-spray type, having no moving parts or restrictors that will promote clogging.

I. Cell Partitions:

1. The tower shall be partitioned such that the fan of each cell can be operated and cycled independently of the remaining cells. Partitions shall extend across the tower between cells from sidewall to sidewall, and from the bottom of the fill upward to the underneath side of the fan deck floor.

2. Partitions may be constructed of precast concrete similar to tower shell construction.

J. Access & Safety:

1. The tower shall be designed and equipped to provide access to all components requiring routine inspection and maintenance. All means of access shall conform to OSHA standards.

2. The fan deck of the tower shall be surrounded by a concrete parapet the same height as the fan discharge cylinder, and conforming to OSHA standards.

3. One endwall of the tower shall be equipped with an exterior mounted FRP stairway rising from grade to the fan deck. A FRP caged ladder shall be on the end opposite the stairway.

4. Each cell shall have a galvanized lift-off access hatch in the fan deck floor, and a stainless steel ladder leading down to a landing at the
drift eliminator level. Each landing shall have a lift-off hatch for entry to the top of the fill and distribution level.

5. Fan cylinders shall have removable segments of sufficient size to allow removal of all mechanical equipment components, and shall have a coupling guard, conforming to OSHA standards, to shroud that portion of the driveshaft that extends outside the fan cylinder.

6. Provide a 24” wide FRP grating maintenance walkway on the eliminators from access opening to the center of each cell, and a stainless steel maintenance ladder from the walkway to the gearbox.
PART 1 - GENERAL

1.01 SCOPE OF SERVICES: Performance verification services shall include the measurement of capacity and power requirements at the design operating conditions for the cooling tower.

1.02 TEST FACILITY: Equipment performance verification shall be conducted at the site.

1.03 QUALITY ASSURANCE: Equipment performance verification shall be conducted in accordance with Cooling Tower Institute Bulletin ATC-105.

PART 2 - PRODUCTS

2.01 INSTRUMENT CALIBRATION: Instrument calibration shall be traceable to the National Institute of Standards and Technology.

PART 3 - EXECUTION

3.01 PERFORMANCE TEST: Provide test by a qualified independent testing agency, for non-certified cooling tower, conducted in presence of the Owner and manufacturer's representatives accordance with ASME PTC-25, or Cooling Tower Institute Bulletin ATC-105 for Water Cooling Towers. Submit qualification of the independent testing agency to the Owner for approval. If the tower does not meet the specified performance, the Manufacturer shall make the tower corrections necessary to bring the tower into compliance with the specified performance including replacing the tower if necessary. Additional tests will be required until the tower meets the specified performance. Costs for the tower corrections or replacements, and tests shall be borne by the Manufacturer.

A. Take air temperatures by mechanically aspirated wet and dry bulb thermometers. Provide sufficient thermometers to read water and air temperatures simultaneously.

B. Appropriate capacity and performance test shall be made to determine compliance with contract requirements. A complete written data report shall be furnished to the Owner.

C. Fan drive shall utilize the specified motor required to produce the full rated cooling tower capacity.

3.02 REPORT: The Supplier shall document the performance verification process and results in a written report. The Supplier shall submit four (4) copies of the report to the Owner for review and approval.

3.03 CAPACITY DAMAGES: In the event that a cooling tower fails to produce the capacity stated in the Supplier's bid (no tolerances will be permitted), the
Supplier will pay damages in the amount of $2,000 and the Equipment Capacity stated in the Supplier’s Bid in Tons less the Measured Capacity in Tons.

Capacity Damages = $2,000 x (Stated Tons – Measured Tons).

3.04 DAMAGES: The Supplier shall pay damages directly to the Owner. Damages shall be paid to the Owner within ninety (90) calendar days after the delivery of the cooling tower.
1. Supplier shall indicate on the Bid Form in the designated location a price to extend warranty by up to four (4) additional years to result in a five (5) year period of complete cooling tower warranty protection from initial Project Acceptance.

2. Extended Warranty shall cover the entire tower including materials, replacement oil, equipment, and parts. Warranty will not cover regular scheduled replacement gear oil.

3. Extended Warranty Agreement shall be between the Owner and the equipment manufacturer.
00800 DISCLOSURE FORM
REQUEST FOR BIDS

ELECTRICAL SWITCHGEAR AND TRANSFORMERS

University of Arkansas
Fayetteville, Arkansas

March 6, 2002

TME Project No. 01-166
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1. The University of Arkansas (the Owner) is soliciting bids from equipment suppliers ("Suppliers") to furnish specified electrical switchgear and transformers for the University of Arkansas Southwest Central Plant

2. Sealed bids will be received at the University of Arkansas, Office of Business Affairs, Administration Building Room 321, Fayetteville, Arkansas 72701 until 2:00 P.M., March 27, 2002.

3. Bids will be received and evaluated privately. Suppliers submitting bids will be notified of selection within thirty (30) calendar days after designated closing time for the receipt of bids.

4. Copies of the bid documents may be obtained at the Office of Business Affairs and offices of TME Consulting Engineers, 5800 Evergreen Drive Suite A; Little Rock, Arkansas 77205.

5. Bids may not be withdrawn for a period of ten (10) days after the designated closing time for the receipt of bids.

6. The Owner reserves the right to reject any or all bids and to waive any formality or irregularity in any bid.
1. **Selection Criteria:** Bids will be evaluated based upon equipment cost, estimated installation costs, physical dimensions, estimated maintenance costs, and conformance with the specifications. Selection will be made based on lowest cost bid meeting the specifications.

2. **Southwest Central Plant:** The electrical gear will be installed in the new Southwest Central Plant at the University of Arkansas. The Architect for the project is Browning Day Mullins Deirdorf Architects. The Engineer for the project is TME Consulting Engineers. The General Contractor for the project will be selected by competitive bid process.

3. **Purchasing Instructions for Electrical Gear:** The University of Arkansas will purchase the switchgear and transformers from the selected Supplier. The installation of the gear will be included in the Southwest Central Plant project. The Contractor for the Southwest Central Plant will be selected using a competitive bidding process. The Contractor will be instructed by the Contract Documents for the Southwest Central Plant project to receive and install equipment. The Supplier shall process, through the Engineer, the equipment submittal documents (shop drawings and maintenance manuals), and coordinate equipment delivery with Contractor.

4. **Laws and Regulations:** The selection and procurement of the equipment is subject to all applicable State laws, municipal ordinances, and rules and regulations of authorities having jurisdiction. Bids shall be structured to comply with these requirements.

5. **Form:** Bids shall be made on the form included in the Request for Bids. Bids shall be submitted in a sealed envelope. Each envelope shall be clearly marked to indicate the name of the Supplier.

6. **Content:** Each Bid shall contain as a minimum the following information:
   
   A. Physical description of the proposed equipment (Refer to Section 00400 for additional information).
   
   B. Specified data for the gear describing capacity and temperature rise for transformers; bus size, size and numbers of breakers in the double ended switchgear; and bus size, size and numbers of switches for the high voltage switchgear (Refer to Section 00400 for additional information).
   
   C. Detailed listing and description of the factory recommendations concerning scheduled (preventative) maintenance services.
   
   D. A complete list of references where equipment of similar configuration and capacity has been installed.
   
   E. A completed Disclosure Form (Refer to Section 00500).
   
   F. A completed Bid Form.

7. **Existing Conditions:** Before submitting a Bid, Supplier shall thoroughly examine the Bid Documents. Suppliers shall fully inform themselves of all conditions and
requirements and shall include in their Bids an amount that is sufficient to cover all such items.

8. **Delivery of Bids:** Bids shall be delivered by the time and to the place stipulated in the Request for Bids. It is the sole responsibility of the Supplier to ensure that the Bid or Bids are received in proper time. Any Bid received after the scheduled closing time for receipt of bids shall be returned to the Supplier unopened.

9. **Withdrawal:** Any Supplier may withdraw their Bid, either personally or by written request, at any time prior to the scheduled closing time for receipt of Bids.

10. **Interpretation of Documents:** If any person contemplating submitting a Bid is in doubt as to the true meaning of any part of the Request for Bids, or finds discrepancies or omissions, he may submit to the Owner’s representative, TME Consulting Engineers, a written request for an interpretation or correction thereof. The person submitting the request will be responsible for its prompt delivery. Any interpretation or correction of the documents will be made only by Addendum duly issued and a copy of the Addendum will be mailed or delivered to each person receiving a Request for Bids. The Owner will not be responsible for any other explanations or interpretations of the Request for Bids.

11. **Addenda:** Any Addenda issued during the time of submission of Bids, shall be covered in the Bid and shall be made a part of the Contract. The supplier on the Bid Form in the location provided shall acknowledge receipt of each Addendum.

12. **Delivery:** It is anticipated that the successful Supplier will receive a purchase order to purchase the selected equipment by not later than April 4, 2002. The submittal documents for the equipment shall be submitted by the Supplier to TME Consulting Engineers for processing and approval by not later than fourteen (14) calendar days after the receipt of the Purchase Order. The Supplier shall be prepared and capable of making delivery, if required by the Contractor, to the project site not later than August 26, 2002. The time and date of delivery of the equipment shall be coordinated between the Supplier and the Southwest Central Plant Contractor. Failure by the Supplier to make delivery within the specified time frame (if required by the Contractor) shall result in the assessment of liquidated damages in the amount of $200 per calendar day. The Supplier shall pay these damages directly to the Owner.

13. **Sales Tax:** Bids shall include applicable sales tax.

14. **Project Acceptance for the Southwest Central Plant Project:** The date of Project Acceptance for the Southwest Central Plant Project shall be date on which the Engineer (TME), and the Owner accept the project and approve the payment final retainage the General Contractor.

15. **Payment Terms for Equipment:** The Supplier shall receive payment for the Equipment (including the first year warranty) from the University of Arkansas at Fayetteville. The Supplier shall receive a partial payment in the amount of 90% of the contract amount within thirty (30) calendar days after the delivery of the equipment. The Supplier shall receive a final payment in the amount of 10% of the contract amount within thirty (30) days after the applicable date of Project Acceptance.

16. **Price Escalation and Carrying Charges:** The amounts indicated on the Bid Form for Equipment shall be inclusive of all required price escalation and
carrying charges associated with the timing of the equipment purchase and the specified partial payments. Payments for these items will be made at the stipulated amount. No adjustments for price escalation and / or carrying charges will be made.

17. **Bid Acceptance**: Pricing for Equipment shall be valid until the dates indicated for the receipt of a purchase order.

18. **Failure to Receive a Purchase Order**: In the event that the selected Supplier fails to receive a Purchase Order for the equipment prior to the date indicated above, the selected Supplier and the Owner shall be unconditionally released of all obligations. The Supplier and the Owner, however, may decide to proceed with the purchase based upon revised terms and conditions that are agreeable to both parties.

19. **Termination of the Equipment Purchase by the Owner for Convenience**: The Owner may elect to terminate the purchase of the equipment for convenience and without cause at any time. Upon receipt of written notice from either the Owner or the Contractor of such termination, the Supplier shall immediately terminate all Purchase Orders and enter into no further Purchase Orders. If such termination for convenience occurs after the receipt of a Purchase Order by the Supplier from the Contractor, the Supplier shall be entitled to recover payment for proven loss associated with respect to submittal preparation, materials, labor, tools, and equipment including reasonable overhead, profit, and damages. If such termination for convenience occurs prior to the receipt of a Purchase Order, the Supplier shall not be entitled to recover payment for any type of loss or damage.

20. **Termination of the Equipment Purchase by the Owner for Cause**: The Owner may elect to terminate the purchase of the equipment for cause if the Supplier either (1) disregards laws, ordinances, or rules, regulations or orders of a public authority having jurisdiction or (2) is otherwise guilty of a substantial breach of a provision of the Bid Documents. If the purchase is terminated by the Owner for cause, the Owner shall be entitled to recover payment from the Supplier for proven loss.

21. **Shop Drawings, Submittal Documents, and Maintenance Manuals**: The selected Supplier shall furnish to the Contractor eight (8) copies of shop drawings, submittal documents, and maintenance manuals (refer to Section 00400 – Equipment Specifications for Additional information).

22. **Ownership and Responsibility**: The Supplier shall be responsible for all arrangements and costs associated with equipment including freight, insurance, and taxes until delivery to the project site and signed acceptance by the Contractor’s representative. Place of delivery shall be the University of Arkansas, Southwest Chiller Plant; Fayetteville, Arkansas 72205. Equipment title shall pass to the Owner at the place of delivery upon signed acceptance by the Owner’s representative (equipment is shipped "FOB Site"). Shipment "FOB Factory" with full freight allowed will not be acceptable.
Bid of ____________________________
(Hereinafter called “Supplier”) corporation, organized and existing under the laws of the state of ____________________________ partnership, or and individual doing business as ____________________________.

To: Office of Business Affairs
    University of Arkansas
    Administration Building, Room 321
    Fayetteville, AR 72701

Gentlemen:
The Supplier, in compliance with your Request for Bids to purchase equipment for the University of Arkansas, having examined the Bid Documents and being familiar with all conditions of these documents, hereby proposes to furnish equipment in accordance with the Bid Documents, within the time set forth therein, and at the prices stated below.

Supplier acknowledges receipt of the following Addenda:

________________________________________________________

Equipment Bid:
Supplier agrees to furnish the medium voltage (15kv) switchgear, low voltage (460v) double ended switchgear and transformers as described in the Bid Documents for the total sum of:

________________________________________________________

________________________________________________________ Dollars ($__________________________)
Supplier understands that the Owner reserves the right to reject any or all Bids and to waive any formalities in the Bids.

(Seal if by corporation)    Respectfully submitted,

________________________________________
Business Address                     Supplier

Date:_______________________________, 2002    By:_______________________________

Title:_______________________________
SECTION 16325 - DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL
1.01 SECTION INCLUDES:
   A. Liquid filled pad mounted distribution transformers.

1.02 RELATED SECTIONS:
   A. Section 03300 - Cast-In-Place Concrete: Pads for transformer support.

1.03 REFERENCES:
   B. ANSI C57.12.00 - General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.
   C. ANSI C57.12.28 - Switchgear and Transformers - Pad Mounted Equipment - Enclosure Integrity.
   H. IEEE 386 - Separable Insulated Connector Systems for Power Distribution Systems Above 600 V.
   J. NFPA 70 - National Electrical Code.

1.04 SUBMITTALS FOR REVIEW:
   A. Section 16010: Procedures for submittals.
   B. Shop Drawings: Indicate electrical characteristics and connection requirements, outline dimensions, connection and support points, weight, specified ratings and materials.
   C. Product Data: Provide electrical characteristics and connection requirements, standard model design tests, and options.
D. Test Reports: Indicate procedures and results for specified factory and field testing and inspection.
E. Submit manufacturer's installation instructions.
F. Manufacturer's Certificate: Certify that Products meet or exceed specified requirements.
G. Manufacturer's Field Reports: Indicate activities on site, final adjustments and overcurrent protective device coordination curves, adverse findings, and recommendations.

1.05 PROJECT CLOSEOUT SUBMITTALS:
A. 16010 - Operation and Maintenance Data: Submittals for project closeout.
B. Include copy of manufacturer's certified drawings in project record documents.
C. Maintenance Data: Include maintenance instructions for cleaning methods; cleaning materials recommended; procedures for sampling and maintaining fluid.

1.06 QUALIFICATIONS:
A. Manufacturer: Company specializing in manufacturing the Products specified in this Section with a minimum ten (10) years documented experience.
B. Testing Agency: Company member of International Electrical Testing Association and specializing in testing products specified in this Section with a minimum five (5) years documented experience.

1.07 DELIVERY, STORAGE, AND HANDLING:
A. Accept transformers on site. Inspect for damage.

1.08 FIELD MEASUREMENTS:
A. Verify that field measurements are as indicated on shop drawings.

1.09 MAINTENANCE MATERIALS:
A. Furnish two (2) each of any special tools required to operate and maintain transformer.

PART 2 - PRODUCTS
2.01 MANUFACTURERS:
A. Square D
B. ABB
C. Engineer Approved Equal

2.02 PAD MOUNTED TRANSFORMERS:
A. Liquid-filled Transformers: ANSI C57.12.22; three phase, pad mounted, self-cooled transformer unit.
B. Capacity: 2500 kVA, two (2) total shall be supplied for this project.
C. Primary Voltage: 12,470 volts, delta connected; provide standard primary taps, with externally-operated tap changer, 65 degrees C rise.
D. Secondary Voltage: 480Y277 volts, three phase, four wire, wye connected.
E. Impedance: 5.75 percent.
F. Basic Impulse Level: 60 kV.
G. Cooling and Temperature Rise: ANSI C57.12.22; Class OA. 65 degrees C, self-cooled.
H. Liquid: High fire point liquid, non-PCB.
I. Accessories: ANSI C57.12.22; standard accessories and magnetic liquid level gage, dial type thermometer.
J. Primary Over current Protection: Current-limiting fuses to ANSI C37.47.
K. Secondary Terminations: Spade lugs for 11 sets #500 MCM copper cable.
L. Primary and secondary windings shall be copper.

2.03 SERVICE CONDITIONS:
A. Meet requirements for usual service conditions described in ANSI C57.12.00.
B. Maximum Ambient Temperature: 104 degrees F, 40 degrees C.
C. Load Current Harmonic Factor: .05 per unit, maximum.

2.04 FABRICATION:
A. Conform to the requirements of ANSI C57.12.28.

2.05 SOURCE QUALITY CONTROL:
A. Provide factory approved testing and analysis.
B. Provide factory tests to ANSI C57.12.90. Include routine tests as defined in ANSI C57.12.00 and the following other tests:
   1. Impedance voltage and load loss.
   2. Dielectric tests.
   3. Audible sound level.
   4. Short circuit capability.
   5. Telephone influence factor (TIF).
C. Test insulating liquid samples in accordance with IEEE C57.106.

PART 3 - EXECUTION
3.01 EXAMINATION:
A. The Contractor shall verify that support pads and conduit are installed and ready to receive transformers.

3.02 INSTALLATION:
A. Install plumb and level.
B. Install safety labels to NEMA 260.

3.03 FIELD QUALITY CONTROL:
A. The Contractor shall inspect and test in accordance with NETA ATS, except Section 4.
B. The Contractor shall perform inspections and tests listed in NEMA ATS, Section 7.2. Include the following optional tests:
   1. Power factor or dissipation-factor tests in accordance with manufacturer's instructions.
   2. Winding-resistance tests for each winding at nominal tap setting.
   3. Individual excitation current tests on each phase.
   4. Insulating liquid specific gravity, water content, dissolved gas, and total combustible gas.
   5. Percent oxygen test on nitrogen gas blanket.

3.04 ADJUSTING:
A. The Contractor shall adjust primary taps so that secondary voltage is above and within 2 percent of rated voltage.

END OF SECTION
SECTION 16340 – MEDIUM VOLTAGE METAL-CLAD SWITCHGEAR

PART 1 – GENERAL

1.01 SECTION INCLUDES:
   A. Medium voltage 15 kV freestanding metal-clad switchgear with vacuum circuit breakers.

1.02 REFERENCES
   A. ANSI/IEEE C37.20.2 - Standard for Metal-Clad Switchgear.
   B. ANSI/IEEE C37.04 and .06 - Standard ratings and preferred ratings for Indoor AC Medium-Voltage Circuit Breakers used in Metal-Clad Switchgear.
   C. ANSI/IEEE C37.11 - Requirements for electrical control for AC High-Voltage Circuit Breakers rated on a symmetrical current basis or a total current basis.
   E. ANSI Z55.1 - Gray Finishes for Industrial Apparatus and Equipment.
   F. ANSI/IEEE C57.13 - Requirements for Instrument Transformers.
   G. NEMA SG4 - Alternating Current High Voltage Circuit Breakers.
   H. NEMA SG5 - Power Switchgear Assemblies.

1.03 SUBMITTALS: Submit shop drawings indicating outline dimensions, enclosure construction, shipping splits, lifting and supporting points, electrical single line diagram, and equipment electrical ratings.

1.04 OPERATION AND MAINTENANCE DATA: Include circuit breaker recommended spare parts list.

1.05 QUALITY ASSURANCE: Manufacturer: Company specializing in medium voltage metal-clad switchgear with at least five years documented experience. The manufacturer of the switchgear must be the same as the manufacturer of the circuit breaker.

1.06 DELIVERY, STORAGE, AND HANDLING
   A. Accept equipment on site and inspect for shipping damage.
   B. Protect equipment from weather and moisture by covering with heavy plastic or canvas and by maintaining heat within enclosure in accordance with manufacturer's instructions.

1.07 EXTRA MATERIALS/ACCESSORIES
   A. Submit one (1) racking handle with equipment. Charging handle to be furnished on each breaker mechanism.
   B. Provide one (1) set of spare control fuses for each set installed.
   C. For all switchgear with circuit breakers in upper compartments, provide one (1) circuit breaker lifting device - portable, floor-supported with a roller base. Also provide same portable lifting device with each outdoor non-
PART 2 - PRODUCTS

2.01 MANUFACTURERS: The metal-clad switchgear shall be manufactured by Square D, General Electric or S & C.

2.02 METAL-CLAD SWITCHGEAR ASSEMBLY:

A. The metal-clad switchgear shall consist of an indoor enclosure containing circuit breakers and the necessary accessory components all factory assembled (except for necessary shipping splits) and operationally checked. The assembly shall be a self-supporting and floor mounted on a level concrete pad. The integrated switchgear assembly shall withstand the effects of closing, carrying and interrupting currents up to the assigned maximum short circuit rating.

B. System Voltage: 12470 kV nominal, three-phase grounded, 60 Hz.

C. Maximum Design Voltage: 15 kV.

D. Impulse Withstand (Basic Impulse Level): 60 kV.

E. Power Frequency Withstand: 19 kV, 1 minute test.

F. Main Bus Ampacity: 1200amps, continuous.

G. Momentary Current Ratings: Equal to the circuit breaker close and latch rating.

2.03 COMPONENTS:

A. Stationary Structure:

1. The switchgear shall consist of four (4) sections including one (1) main 1200A circuit breaker section, one (1) section with two (2) 200 ampere vacuum circuit breakers, and two (2) sections with space for two (2) 200 ampere vacuum circuit breakers each assembled to form a rigid self-supporting completely enclosed structure providing steel barriers between sections. Main shall be in the left most section. The two (2) 200A circuit breakers shall be in the second from the left section.

2. The sections are divided by metal barriers into the following separate compartments: Circuit breaker, instrument, main bus, auxiliary device and cable. Each feeder section may have up to two circuit breaker compartments.

B. Circuit Breaker Compartment:

1. Each circuit breaker compartment shall be designed to house a horizontal drawout metal-clad vacuum circuit breaker. The stationary primary disconnecting contacts are to be silver-plated copper and mounted within glass polyester support bushings. The movable contacts and springs shall be mounted on the circuit breaker element for ease of inspection/maintenance.

2. Entrance to the stationary primary disconnecting contacts shall be automatically covered by metal shutters when the circuit breaker is
withdrawn from the connected position to the test or disconnected position or removed from the circuit breaker compartment. Extend a ground bus into the circuit breaker compartment to automatically ground the breaker frame with high-current spring type grounding contacts located on the breaker chassis when in the test and connected positions. Guide rails for positioning the circuit breaker and all other necessary hardware are to be an integral part of the circuit breaker compartment. Blocking devices shall interlock breaker frame sizes to prevent installation of a lower ampere rating or interrupting capacity element into a compartment designed for one of a higher rating. It shall be possible with indoor or outdoor walk-in switchgear to install a circuit breaker into a bottom compartment without use of a transport truck or lift device.

C. Cable Compartment/Ground Bus: Compression type cable lugs shall be furnished. The ground bus shall extend through this compartment for the full length of the switchgear. Auxiliary bus, if needed, and load bus support NEMA Class A-20 standoff insulators shall be epoxy.

D. Main Bus Compartment: The main bus is to be rated 1200 amps and be fully insulated for its entire length with an epoxy coating by the fluidized bed process. The conductors are to be silver-plated copper and be of a bolted design. Access to this compartment is gained from the front or rear of the structure by removing a steel barrier. Provide standard provisions for future extension, as applicable.

E. Doors and Panels: Relays, meters, control switches, etc., shall be mounted on a formed front-hinged panel for each circuit breaker compartment.

F. Circuit Breakers:

1. The circuit breakers shall be rated 12,470 nominal volts, 15,000 maximum volts, 60 Hz, with a continuous current rating of 1200 amps and a maximum symmetrical interrupting rating of 36kA/750MVA - 15 kV system. Furnish Type VR circuit breakers with one vacuum interrupter per phase. Breakers of same type and rating shall be completely interchangeable. The circuit breaker shall be operated by means of a stored energy mechanism which is normally charged by a universal motor but can also be charged by the manual handle supplied on each VR breaker for manual emergency closing or testing. The closing speed of the moving contacts is to be independent of both the control voltage and the operator. Provide a full front shield on the breaker. Secondary control circuits shall be connected automatically with a self-aligning, self-engaging plug and receptacle arrangement when the circuit breaker is racked into the connected position. Provision shall be made for secondary control plug to be manually connected in test position. A minimum of 4 auxiliary contacts (2a 2b), shall be provided for external use. Provisions shall be made for additional cell-mounted auxiliary contacts MOC type for external use. The racking mechanism to move the breaker between positions shall be operable with the front door closed and position indication shall be visible with door closed. Maximum symmetrical kA interrupting ratings are based on Table 1
of C37.06-1997. MVA ratings are nominal reference values for comparison only.

2. An interlocking system shall be provided to prevent racking a closed circuit breaker to or from any position. An additional interlock shall automatically discharge the stored-energy operating mechanism springs upon removal of the breaker out of the compartment.

3. The circuit breaker control voltage shall be: 120 volts AC. Provide one capacitor trip unit for each circuit breaker when AC control power is required.

G. Instrument Transformers:
   1. Current transformers: Each breaker compartment shall have provision for front-accessible mounting of up to four current transformers per phase* (ANSI standard relay accuracy), two on bus side and two on cable side of circuit breaker. The current transformer assembly shall be insulated for the full voltage rating of the switchgear. The current transformers wiring shall be Type SIS #12 AWG. Relaying and metering accuracy shall conform to ANSI Standards.
   2. Voltage transformers are drawout mounted with primary current-limiting fuses and shall have ratio as indicated. The transformers shall have mechanical rating equal to the momentary rating of the circuit breakers and shall have metering accuracy per ANSI Standards.

   * High accuracy and/or ratios below 150:5, two per phase.

H. Control Wiring: The switchgear shall be wired with type SIS #14 AWG, except where larger size wire is specified. The switchgear shall be provided with terminal blocks for outgoing control connections. Wire markers shall be provided for each end of all control wires.

I. Ammeters: ANSI C39.1; indicating ammeter with 4.5 in square recessed case and 250° scale, white dial with black figures and pointer, 5 amp, 60 Hz movement, 1% accuracy.

J. Voltmeters: ANSI C39.1; indicating voltmeter with 4.5 in square recessed case and 250° scale, white dial with black figures and pointer, 120 volt, 60 Hz movement, 1% accuracy.

K. Ammeter Transfer Switch: Rotary multistage detent type with 600 volt ac-dc silver plated contacts, engraved escutcheon plate, pistol-grip handle and four positions including OFF.

L. Voltmeter Transfer Switch: Rotary multistage detent type with 600 volt ac-dc silver plated contacts, engraved escutcheon plate, pistol-grip handle, and four positions including OFF.

2.04 FABRICATION:

A. Construction: Each equipment bay shall be a separately constructed cubicle assembled to form a rigid freestanding unit. Minimum sheet metal thickness shall be 11 gauge steel on all exterior surfaces. Adjacent bays shall be securely bolted together to form an integrated rigid structure.
rear covers shall be removable to assist installation and maintenance of bus and cables. Each individual unit shall be braced to prevent distortion.

B. Dimensions: Standard dimensions per indoor section are: 36 in W x 95 in H x 92 in D

C. The metal-clad switchgear shall be fully assembled, inspected and tested at the factory prior to shipment. Large line-ups shall be split to permit normal shipping and handling as well as for ease of rejoining at the job site.

2.05 FACTORY FINISHING:

A. All steel parts, except galvanized (if used), shall be cleaned and a zinc-phosphate pre-treatment applied prior to paint application.

B. Paint color shall be ANSI-61 light grey; TGIC polyester powder, applied electrostatically through air. Following paint application, parts shall be baked to produce a hard durable finish. The average thickness of the paint film shall be 2.0 mils. Paint film shall be uniform in color and free from blisters, sags, flaking and peeling.

C. Adequacy of paint finish to inhibit the buildup of rust on ferrous metal materials shall be tested and evaluated per paragraphs 5.2.8.1-7 of ANSI C37.20.2-1987. Salt spray withstand tests in accordance with ASTM #D-1654 and #B-117 shall be performed on a periodic basis to provide conformance with the corrosion resistance standard of at least 4000 hours minimum.

PART 3 - EXECUTION

3.01 EXAMINATION:

A. Visually inspect switchgear for evidence of damage and verify that surfaces are ready to receive work.

B. Visually inspect to confirm that all items and accessories are in accordance with specifications.

C. Verify field measurements are as shown on shop drawings.

D. Verify that required utilities (e.g., control voltage for heater circuits on outdoor switchgear) are available, in proper location, and ready for use.

E. Beginning of installation means installer accepts existing surface conditions.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions, applicable requirements of the NEC and in accordance with recognized industry practices.

B. Bending of high-voltage cables should be avoided or minimized. All necessary bends should meet at least the minimum radii specified by the cable manufacturer.

3.03 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed by the installing contractor.
B. Visually inspect for physical damage.
C. Perform start-up tests in accordance with manufacturer's instruction manual.
D. Touch-up paint all chips and scratches with manufacturer-supplied paint and leave remaining paint with owner.
E. Verify key interlock operation.
F. Perform low frequency withstand (Hi-Pot) tests according to ANSI/IEEE C37.20.2, paragraph 5.5.

END OF SECTION
SECTION 16440 - SWITCHBOARDS

PART 1 – GENERAL

1.01 SECTION INCLUDES:

A. Distribution Switchboard: Furnish and install the switchboard as herein specified.

1.02 REFERENCES:

A. The switchboard and overcurrent protection devices referenced herein are designed and manufactured according to the following appropriate specifications.

1. ANSI/NFPA 70 - National Electrical Code (NEC).
2. ANSI/IEEE C12.16 - Solid-State Electricity Metering.
3. ANSI C57.13 - Instrument Transformers.
4. NEMA AB 1 - Molded Case Circuit Breakers and Molded Case Switches.
5. NEMA PB 2 - Deadfront Distribution Switchboards, File E8681
6. NEMA PB 2.1 - Proper Handling, Installation, Operation and Maintenance of Deadfront Switchboards Rated 600 Volts or Less.
8. UL 50 - Cabinets and Boxes.
9. UL 98 - Enclosed and Dead Front Switches.
10. UL 489 - Molded Case Circuit Breakers.
11. UL 891 - Dead-Front Switchboards.
12. UL 943 - Standard for Ground Fault Circuit Interrupters.

1.03 SUBMITTALS: Shop Drawings shall indicate front and side enclosure elevations with overall dimensions shown; conduit entrance locations and requirements; nameplate legends; one-line diagrams; equipment schedule; and switchboard instrument details.

1.04 QUALIFICATIONS:

A. To be considered for approval, a manufacturer shall have specialized in the manufacturing and assembly of switchboards for at least fifty (50) years.

B. Furnish products listed by Underwriters Laboratories Incorporated and in accordance with standards listed in Article 1.03 - References.

C. The manufacturing facility shall be registered by Underwriters Laboratories Inc. to the International Organization for Standardization ISO 9002 Series Standards for quality.
1.05 DELIVERY, STORAGE, AND HANDLING:
   A. Deliver, store, protect, and handle products in conformance with manufacturer's recommended practices as outlined in applicable Installation and Maintenance Manuals.
   B. Each switchboard section shall be delivered in individual shipping splits for ease of handling. They shall be individually wrapped for protection and mounted on shipping skids.
   C. Inspect and report concealed damage to carrier within their required time period.
   D. Store in a clean, dry space. Maintain factory protection and/or provide an additional heavy canvas or heavy plastic cover to protect structure from dirt, water, construction debris, and traffic. Where applicable, provide adequate heating within enclosures to prevent condensation.
   E. Handle in accordance with NEMA PB 2.1 and manufacturer's written instructions. Lift only by lifting means provided for this express purpose. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.

1.06 ENVIRONMENTAL REQUIREMENTS: Conform to NEMA PB 2 service conditions during and after installation of switchboards.

1.07 MAINTENANCE MATERIALS: Provide one (1) set of installation and maintenance instructions with each switchboard. Instructions are to be easily identified and affixed within the incoming or main section of the line-up.

1.08 WARRANTY: Manufacturer shall warrant equipment to be free from defects in materials and workmanship for the lesser of one (1) year from date of installation or eighteen (18) months from date of purchase.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:
   A. Switchboard shall be manufactured as herein specified and shall be Square D, General Electric, Cutler Hammer or Engineer approved equal.
   B. Substitutions must be submitted in writing three (3) weeks prior to original bid date with supporting documentation demonstrating that the alternate manufacturer conforms to all aspects of the specifications herein.

2.02 SWITCHBOARD – GENERAL:
   A. Short Circuit Current Rating: Switchboards shall be rated with a minimum short circuit current rating of 65,000 RMS symmetrical amperes at 480 VAC maximum.
   B. Future Provisions: All unused spaces provided, unless otherwise specified, shall be fully equipped for future devices, including all appropriate connectors and mounting hardware.
   C. Enclosure: Type 1 - General Purpose.
      1. Sections shall be aligned front and rear.
2. Removable steel base channels (1.5 inch floor sills) shall be bolted to the frame to rigidly support the entire shipping section for moving on rollers and floor mounting.

3. The switchboard enclosure shall be painted on all exterior surfaces. The paint finish shall be a medium gray, ANSI #49, applied by the electro-deposition process over an iron phosphate pre-treatment.

4. All front covers shall be screw removable with a single tool and all doors shall be hinged with removable hinge pins.

5. Top and bottom conduit areas shall be clearly indicated on shop drawings.

D. Nameplates: Provide 1 inch high x 3 inches engraved laminated (Gravoply) nameplates for each device. Furnish black letters on a white background for all voltages.

E. Bus Composition: Shall be plated copper. Plating shall be applied continuously to all bus work. The switchboard bussing shall be of sufficient cross-sectional area to meet UL Standard 891 temperature rise requirements. The phase and neutral through-bus shall have an ampacity as shown in the plans. For 4-wire systems, the neutral shall be of equivalent ampacity as the phase bus bar. Tapered bus is not acceptable. Full provisions for the addition of future sections shall be provided. Bussing shall include all necessary hardware to accommodate splicing for future additions.

F. Ground Bus: Sized per NFPA70 and UL 891 Tables 25.1 and 25.2 and shall extend the entire length of the switchboard. Provisions for the addition of future sections shall be provided.

2.03 SWITCHBOARD - INCOMING MAIN SECTION DEVICES:

A. Main Circuit Breaker: Thermal magnetic molded case circuit breaker(s) through 3000A.
   1. Molded case circuit breakers shall have integral thermal and instantaneous magnetic trip in each pole.
   2. Circuit protective devices shall be switchboards manufacturer’s molded case circuit breakers. Circuit breakers shall be high interrupting. Ampere ratings shall be as shown.

2.04 SWITCHBOARD - DISTRIBUTION SECTION DEVICES:

A. Group Mounted Circuit Breakers Through 1200A:
   1. Circuit breaker(s) shall be group mounted plug-on with mechanical restraint on a common pan or rail assembly.
   2. The interior shall have three flat bus bars stacked and aligned vertically with glass reinforced polyester insulators laminated between phases. The molded polyester insulators shall support and provide phase isolation to the entire length of bus.
   3. Circuit breaker(s) equipped with line terminal jaws shall not require additional external mounting hardware. Circuit breaker(s) shall be held in mounted position by a self-contained bracket secured to the
mounting pan by fasteners. Circuit breaker(s) of different frame sizes shall be capable of being mounted across from each other.

4. Line-side circuit breaker connections are to be jaw type.

5. All unused spaces provided, unless otherwise specified, shall be fully equipped for future devices, including all appropriate connectors and mounting hardware.

6. Thermal magnetic molded case circuit breakers:
   a. Molded case circuit breakers shall have integral thermal and instantaneous magnetic trip in each pole.
   b. Circuit protective devices shall be switchboard manufacturer’s molded case circuit breaker(s). Circuit breaker(s) shall be high interrupting. Ampere ratings shall be as shown.

B. Individually Mounted Circuit Breakers:
   1. Thermal magnetic molded case circuit breakers:
      a. Molded case circuit breakers shall have integral thermal and instantaneous magnetic trip in each pole.
      b. Circuit protective devices shall be switchboard manufacturer’s molded case circuit breaker(s). Circuit breaker(s) shall be high interrupting. Ampere ratings shall be as shown.

2.05 CONFIGURATION:

A. Double ended switchboard shall be configured as follows (from left to right):
   1. Section 1 - One (1) 3000-ampere main circuit breaker, 3 pole.
   2. Section 2 – Two (2) 1200-ampere circuit breakers, 3 pole.
   3. Section 3 – Distribution:
      a. Four (4) 125-ampere circuit breakers, 3 pole.
      b. Two (2) 100-ampere circuit breakers, 3 pole.
      c. One (1) 175 ampere circuit breaker, 3 pole.
      d. The rest of the section is space for additional circuit breakers.
   4. Section 4 – Tie (N.O.)
   5. Section 5 – Distribution
      a. Four (4) 125-ampere circuit breakers, 3 pole.
      b. Two (2) 100-ampere circuit breakers, 3 pole.
      c. One (1) 175 ampere circuit breaker, 3 pole.
      d. The rest of the section is space for additional circuit breakers.
   6. Section 6 - Two (2) 1200-ampere circuit breakers, 3 pole.
   7. Section 7 - (1) 3000 ampere main circuit breaker, 3 pole.
PART 3 - EXECUTION

3.01 INSPECTION:
A. Examine area to receive switchboard to provide adequate clearance for switchboard installation.
B. Check that concrete pads are level and free of irregularities.
C. Start work only after unsatisfactory conditions are corrected.

3.02 INSTALLATION: Ensure installation of switchboard is in accordance with manufacturer's written guidelines, the NEC, and local codes.

3.03 FIELD QUALITY CONTROL:
A. Inspect completed installation for physical damage, proper alignment, anchorage, and grounding.
B. Measure, using a Megger, the insulation resistance of each bus section phase-to-phase and phase-to-ground for one minute each, at minimum test voltage of 1000 VDC; minimum acceptable value for insulation resistance is 1 megohms. Refer to manufacturer's literature for specific testing procedures.
C. Check tightness of accessible bolted bus joints using calibrated torque wrench per manufacturer's recommended torque values.
D. Physically test key interlock systems to check for proper functionality.
E. Test ground fault systems by operating push-to-test button.

3.04 ADJUSTING:
A. Adjust all operating mechanisms for free mechanical movement per manufacturer's specifications.
B. Tighten bolted bus connections in accordance with manufacturer's instructions.
C. Adjust circuit breaker trip and time delay settings to values indicated as provided by the Engineer of Record.

3.05 CLEANING: Touch up scratched or marred surfaces to match original finish.

END OF SECTION
00500 – DISCLOSURE FORM
REQUEST FOR BIDS

WATER CHILLERS

University of Arkansas
Fayetteville, Arkansas

April 1, 2002

TME Project No. 01-166
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* An Excel spreadsheet file entitled “Water Chiller Proposal Evaluation” is also attached to this document..
1. The University of Arkansas (the Owner) is soliciting Bids from equipment suppliers ("Suppliers") to furnish (3) three water chillers for the University of Arkansas Southwest Central Plant

2. Sealed Bids will be received at the University of Arkansas, Office of Business Affairs, Administration Building Room 321, Fayetteville, Arkansas 72701 until 2:00 P.M., April 4, 2002.

3. Bids will be received and evaluated privately. Suppliers submitting Bids will be notified of selection within thirty (30) calendar days after designated closing time for the receipt of Bids.

4. Copies of the Request for Bids may be obtained at the Office of Business Affairs and offices of TME Consulting Engineers, 5800 Evergreen Drive Suite A; Little Rock, Arkansas 77205.

5. Bids may not be withdrawn for a period of ten (10) days after the designated closing time for the receipt of Bids.

6. The Owner reserves the right to reject any or all Bids and to waive any formality or irregularity in any Bid.
1. **Evaluation Criteria:** Bids will be evaluated based upon physical size, equipment cost, delivery date, energy efficiency, evaporator and condenser water pressure drops, estimated energy costs, estimated maintenance costs, local service capabilities, life cycle cost, and other factors. Life cycle costs will be calculated based upon the equipment performance indicated on the Bid Form and the methods, indices, and factors stipulated in the National Institute of Standards and Technology (NIST) Handbook 135 and the Energy Price Indices and Discount Factors for Life Cycle Cost Analysis 2002 Annual Supplement as indicated in the attached Excel spreadsheet file entitled “Water Chiller Proposal Evaluation”. The responsive (compliant with the requirements of the Request for Bids) Bid that yields the lowest life cycle cost will be selected.

2. **Southwest Central Plant:** The chillers will be installed in the new Southwest Central Plant at the University of Arkansas. The Architect for the project is Browning Day Mullins Deirdorf Architects. The Engineer for the project is TME Consulting Engineers. The General Contractor for the project will be selected by the competitive bid process.

3. **Purchasing Instructions for Water Chillers:** The University of Arkansas will purchase the Water Chillers from the selected Supplier. The University of Arkansas will then assign the installation of the Water Chillers to the successful Contractor for the Southwest Central Plant. The Contractor will be selected using the competitive bidding process. The Contractor will be instructed by the Contract Documents for the Southwest Central Plant project to install the Water Chillers furnished by the selected Supplier in accordance with the terms and conditions of the Request for Bids. The Contract Documents for the Southwest Chiller Plant will require the Contractor to coordinate equipment delivery, unload the equipment, and install the equipment.

4. **Bids:** Suppliers shall submit Bids for Package “A” and Package “B”. The Bids for Package “A” and Package “B” are mutually exclusive. The Owner may accept either a Package “A” Bid or a Package “B” Bid. The Owner will not select a Package “A” Bid and a Package “B” Bid.

5. **Laws and Regulations:** The selection and procurement of the equipment is subject to all applicable State laws, municipal ordinances, and rules and regulations of authorities having jurisdiction. Bids shall be structured to comply with these requirements.

6. **Form:** Bids shall be made on the form included in the Request for Bids. Bids shall be submitted in a sealed envelope. Each envelope shall be clearly marked to indicate the name of the Supplier and the type of Bid (either Package “A” or Package “B”).

7. **Content:** Each Bid shall contain as a minimum the following information:
   A. Physical description of the proposed equipment (refer to Section 00500 for additional information).
B. Performance data for the water chillers at each set of defined operating conditions (refer to Sections 00400, 00410, and 00500 for additional information).

C. Detailed listing and description of the factory recommendations concerning scheduled (preventative) maintenance services (refer to Section 00500 for additional information).

D. Detailed information regarding the Service Organization (refer to Section 00500 for additional information).

E. A complete list of references where equipment of similar configuration and capacity has been installed (refer to Section 00500 for additional information).

F. A completed Disclosure Form (refer to Section 01000).

G. A completed Bid Form.

8. **Existing Conditions:** Before submitting a Bid, Supplier shall thoroughly examine the Request for Bids. Suppliers shall fully inform themselves of all conditions and requirements and shall include in their Bids an amount that is sufficient to cover all such items.

9. **Delivery of Bids:** Bids shall be delivered by the time and to the place stipulated in the Request for Bids. It is the sole responsibility of the Supplier to ensure that the Bid or Bids are received in proper time. Any Bid received after the scheduled closing time for receipt of Bids shall be returned to the Supplier unopened.

10. **Withdrawal:** Any Supplier may withdraw their Bid, either personally or by written request, at any time prior to the scheduled closing time for receipt of Bids.

11. **Interpretation of Documents:** If any person contemplating submitting a Bid is in doubt as to the true meaning of any part of the Request for Bids, or finds discrepancies or omissions, he may submit to the Owner’s representative, TME Consulting Engineers, a written request for an interpretation or correction thereof. The person submitting the request will be responsible for its prompt delivery. Any interpretation or correction of the documents will be made only by Addendum duly issued and a copy of the Addendum will be mailed or delivered to each person receiving a Request for Bids. The Owner will not be responsible for any other explanations or interpretations of the Request for Bids.

12. **Addenda:** Any Addenda issued during the time of submission of Bids, shall be covered in the Bid and shall be made a part of the Contract. The Supplier shall acknowledge receipt of each Addendum on the Bid Forms in the designated location.

13. **Delivery:** It is anticipated that the successful Supplier (or Suppliers) will receive a Purchase Order for the selected equipment by not later than April 12, 2002. The submittal documents for the equipment shall be submitted by the Supplier to TME Consulting Engineers for processing and approval by not later than fourteen (14) calendar days after the receipt of the Purchase Order. The Supplier shall be prepared and capable of making delivery to the site not later than 140 calendar days after the receipt of the Purchase Order. Failure by the Supplier to make delivery within the specified time frame (if required by the Contractor) shall result in the assessment of liquidated damages in the amount of $200 per calendar day. The Supplier shall pay these damages directly to the Owner.
14. **Sales Tax:** Bids shall include applicable sales tax.

15. **Project Acceptance for the Southwest Central Plant Project:** The date of Project Acceptance for the Southwest Central Plant Project shall be the date on which the Engineer (TME) and the Owner accept the project and approve the payment of final retainage to the Contractor.

16. **Identical Equipment:** Each of the water chillers shall be of the same manufacturer, model, refrigerant, capacity, and type. Each water chiller shall be equipped with the same features and components. If one water chiller is to be equipped with a variable frequency drive then all of the water chillers shall be equipped with a variable frequency drive.

17. **Variable Frequency Drives:** The Supplier may elect to submit Bids that are based upon the use of water chillers that are equipped with variable frequency drives. If variable frequency drives are used, the cost of these drives and their installation (refer to Section 00600 for additional information) shall be included in the price for the Base Equipment.

18. **Harmonic Filters:** If the Supplier elects to submit Bids that are based upon the use of water chillers that are equipped with variable frequency drives, the cost of harmonic filters and their installation (refer to Section 00610 for additional information) shall be indicated on the Bid Form in the designated location.

19. **Prices:** Suppliers shall submit the following prices for each Bid: Base Equipment, Harmonic Filters (if applicable), Verification of Performance, Scheduled Maintenance, and Extended Warranty. The prices for Base Equipment and Harmonic Filters (if applicable) shall include the cost of the first year warranty. The Owner reserves the right to accept the price for the Base Equipment and reject any or all of the other prices.

20. **Maximum Equipment Price:** The maximum equipment price (sum of the prices for the Base Equipment and Harmonic Filters if applicable) shall not exceed $650,000 for either Package “A” or Package “B”.

21. **Payment Terms for Equipment:** The Supplier shall receive payment for the Base Equipment and the Harmonic Filters (if applicable) from the Owner. The Supplier shall receive a partial payment in the amount of 90% of the contract amount within thirty (30) calendar days after the delivery of the equipment. The Supplier shall receive a final payment in the amount of 10% of the contract amount within thirty (30) days after the applicable date of Project Acceptance. Project Acceptance is anticipated no later than February 28, 2003.

22. **Payment Terms for Extended Warranty:** The Supplier shall receive payment for the Extended Warranty from the Owner (if accepted by the Owner). The Supplier shall receive a partial payment in the amount of 90% of the contract amount within thirty (30) calendar days after the delivery of the equipment. The Supplier shall receive a final payment in the amount of 10% of the contract amount within thirty (30) days after the applicable date of Project Acceptance.

23. **Payment Terms for Scheduled Maintenance:** The Supplier shall receive payments for Scheduled Maintenance from the Owner (if this Alternate is accepted by the Owner). The Supplier shall receive payments from the Owner for Scheduled Maintenance on a quarterly basis. Each payment shall be 25% of the annual contract amount (including appropriate escalation if applicable).
24. **Price Escalation and Carrying Charges:** The prices indicated on the Bid Form shall be inclusive of all required price escalation and carrying charges associated with the timing of the equipment purchase and the specified partial payments. Payments for these items will be made at the stipulated amount. No adjustments for price escalation and / or carrying charges will be made.

25. **Bid Acceptance:** Prices shall be valid until the dates indicated for the receipt of a purchase order. It is understood that the Supplier’s pricing for the Extended Warranty and Scheduled Maintenance Bids is conditional upon the Owner's acceptance of the Supplier’s price for the associated Base Equipment.

26. **Failure to Receive a Purchase Order:** In the event that the selected Supplier fails to receive a Purchase Order for the equipment prior to the date indicated above, the selected Supplier and the Owner shall be unconditionally released of all obligations. The Supplier and the Owner, however, may decide to proceed with the purchase based upon revised terms and conditions that are agreeable to both parties.

27. **Termination of the Equipment Purchase by the Owner for Convenience:** The Owner may elect to terminate the purchase of the equipment for convenience and without cause at any time. Upon receipt of written notice from the Owner of such termination, the Supplier shall immediately terminate all Purchase Orders and enter into no further Purchase Orders. If such termination for convenience occurs after the receipt of a Purchase Order by the Supplier, the Supplier shall be entitled to recover payment for proven loss associated with respect to submittal preparation, materials, labor, tools, and equipment including reasonable overhead, profit, and damages. If such termination for convenience occurs prior to the receipt of a Purchase Order, the Supplier shall not be entitled to recover payment for any type of loss or damage.

28. **Termination of the Equipment Purchase by the Owner for Cause:** The Owner may elect to terminate the purchase of the equipment for cause if the Supplier either (1) disregards laws, ordinances, or rules, regulations or orders of a public authority having jurisdiction or (2) is otherwise guilty of a substantial breach of a provision of the Request for Bids. If the purchase is terminated by the Owner for cause, the Owner shall be entitled to recover payment from the Supplier for proven loss.

29. **Termination of the Scheduled Maintenance Agreement:** The Owner may elect to terminate the Scheduled Maintenance Agreement by providing (90) ninety days written notice to the Supplier. In the event of Termination, the Supplier will receive payment for services rendered prior to the Termination. The cost of the services rendered prior to Termination will be determined by pro rata allocation of the annual cost.

30. **Shop Drawings, Submittal Documents, and Maintenance Manuals:** The selected Supplier shall furnish to the Contractor eight (8) copies of shop drawings, submittal documents, and maintenance manuals (refer to Section 00500 – Equipment Specifications for Additional information.

31. **Ownership and Responsibility:** The Supplier shall be responsible for all arrangements and costs associated with equipment including freight, insurance, and taxes until delivery to the project site and signed acceptance by the Contractor’s representative. Place of delivery shall be the University of Arkansas, Southwest
Chiller Plant; Fayetteville, Arkansas 72205. Equipment title shall pass to the Owner at the place of delivery upon signed acceptance by the Owner’s representative (equipment is shipped "FOB Site"). Shipment “FOB Factory” with full freight allowed will not be acceptable. Supplier shall notify the Contractor and the designated representative of the Owner a minimum of forty-eight (48) hours prior to delivery.
Bid of ________________________________
(Hereinafter called “Supplier”) corporation, organized and existing under the laws of the state of ____________________________ partnership, or and individual doing business as ____________________________.

To:  Office of Business Affairs
    Administration Building, Room 321
    University of Arkansas
    Fayetteville, AR  72701

Gentlemen:
The Supplier, in compliance with your Request for Bids to purchase equipment for the University of Arkansas, Office of Business Affairs, Room 321; Fayetteville, AR  72701, having examined the Request for Bids and being familiar with all conditions of these documents, hereby proposes to furnish equipment and services in accordance with the Request for Bids, within the time set forth therein, and at the prices stated below.

Supplier acknowledges receipt of the following Addenda:

____________________________________

Base Equipment Price:
Supplier agrees to furnish three (3) water chillers (including installation and start-up assistance and the their first year warranty) as described in the Request for Bids for the total sum of:

____________________________________

____________________________________  Dollars ($________________________)

Harmonic Filters Price:
Supplier agrees to furnish and install harmonic filters (including their first year warranty) for three (3) water chillers if applicable as described in the Request for Bids for the total sum of:

____________________________________

____________________________________  Dollars ($________________________)
Verification of Performance Prices:
Supplier agrees to provide Verification of Performance services for water chillers as described in the Request for Bids for the prices indicated below:

Verification of Performance Service shall be provided for a single water chiller for the sum of

_______________________________________________________________________________

_______________________________________________________________________________ Dollars ($______________________)

Verification of Performance Service shall be provided for two (2) water chillers for the sum of

_______________________________________________________________________________

_______________________________________________________________________________ Dollars ($______________________)

Verification of Performance Service shall be provided for three (3) water chiller for the sum of

_______________________________________________________________________________

_______________________________________________________________________________ Dollars ($______________________)

Extended Warranty Price:
Supplier agrees to furnish the Extended Warranty for three (3) water chillers as described in the Request for Bids for the total sum of:

_______________________________________________________________________________

_______________________________________________________________________________ Dollars ($______________________)

Scheduled Maintenance Price:
Supplier agrees to furnish Scheduled Maintenance for three (3) water chillers as described in the Request for Bids during the first year of equipment operation after start-up for the total annual sum of:

_______________________________________________________________________________

_______________________________________________________________________________ Dollars ($______________________)

The sum will be increased each year thereafter by not more than the annual percentage amount of:

_______________________________________________________________________________
Percent (%)
Water Chiller Evaporator and Condenser Water Pressure Drops:

Equipment Supplier agrees to provide water chillers with maximum water pressure drops as stated below:

Evaporator WPD at 2,000 GPM: __________ feet w.g.
Condenser WPD at 3,000 GPM: __________ feet w.g.

Water Chiller Evaporator and Condenser Water Flow Rates:

Equipment Supplier agrees to provide water chillers with minimum and maximum flow rates as stated below:

Minimum Evaporator Flow Rate: __________ GPM
Maximum Evaporator Flow Rate: __________ GPM
Minimum Condenser Flow Rate: __________ GPM
Maximum Condenser Flow Rate: __________ GPM
**Water Chiller Efficiency:**

Equipment Supplier agrees to provide water chillers with the power requirements indicated below:

**Summer Period:**

<table>
<thead>
<tr>
<th>OSA Temp. (°F)</th>
<th>Load (Tons)</th>
<th>Evaporator</th>
<th>Condenser</th>
<th>Power (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>EWT (°F)</td>
<td>LWT (°F)</td>
<td>Flow (GPM)</td>
</tr>
<tr>
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<td>54</td>
<td>40</td>
<td>1,714</td>
</tr>
<tr>
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<td>52.5</td>
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<td>47.5</td>
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<tr>
<td>42.5</td>
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<td>40</td>
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<td></td>
</tr>
</tbody>
</table>

**Winter Period:**

<table>
<thead>
<tr>
<th>OSA Temp. (°F)</th>
<th>Load (Tons)</th>
<th>Evaporator</th>
<th>Condenser</th>
<th>Power (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>EWT (°F)</td>
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<td>Flow (GPM)</td>
</tr>
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<td></td>
</tr>
<tr>
<td>42.5</td>
<td>870</td>
<td>40</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Suppliers are to complete the tables above. Entering evaporator water temperatures are to be 54 deg. F at the stipulated loads unless the calculated evaporator flow at these conditions is below the minimum. If the calculated evaporator flow based upon a 54 deg. F entering evaporator water temperature is below the minimum, the evaporator minimum flow...
shall be the minimum and the entering evaporator water temperature shall be calculated based upon the stipulated load and the stipulated evaporator leaving water temperature. Condenser water flow rates shall be equal to the product of the stipulated load and 3 GPM per Ton or the minimum whichever is higher.

Supplier understands that the Owner reserves the right to reject any or all Bids and to waive any formalities in the Bids.

(Seal if by corporation)  Respectfully submitted,

______________________________  ________________________________
Business Address                  Supplier

Date:_________________________, 2002  By:____________________________

Title:____________________________
00310 – PACKAGE “B” BID FORM

Bid of

(Hereinafter called “Supplier”) corporation, organized and existing under the laws of the
state of __________________________ partnership, or and individual doing
business as __________________________.

To: Office of Business Affairs
    Administration Building, Room 321
    University of Arkansas
    Fayetteville, AR 72701

Gentlemen:
The Supplier, in compliance with your Request for Bids to purchase equipment for the
University of Arkansas, Office of Business Affairs, Room 321; Fayetteville, AR 72701,
having examined the Request for Bids and being familiar with all conditions of these
documents, hereby proposes to furnish equipment and services in accordance with the
Request for Bids, within the time set forth therein, and at the prices stated below.

Supplier acknowledges receipt of the following Addenda:

______________________________________________________________

Base Equipment Price:
Supplier agrees to furnish three (3) water chillers (including installation and start-up
assistance and the their first year warranty) as described in the Request for Bids for the total
sum of:

______________________________________________________________

______________________________________________________________ Dollars ($________________________)

Harmonic Filters Price:
Supplier agrees to furnish and install harmonic filters (including their first year warranty) for
three (3) water chillers if applicable as described in the Request for Bids for the total sum of:

______________________________________________________________

______________________________________________________________ Dollars ($________________________)
Verification of Performance Prices:
Supplier agrees to provide Verification of Performance services for water chillers as described in the Request for Bids for the prices indicated below:

Verification of Performance Service shall be provided for a single water chiller for the sum of


Verification of Performance Service shall be provided for two (2) water chillers for the sum of


Verification of Performance Service shall be provided for three (3) water chiller for the sum of


Extended Warranty Price:
Supplier agrees to furnish the Extended Warranty for three (3) water chillers as described in the Request for Bids for the total sum of:


Scheduled Maintenance Price:
Supplier agrees to furnish Scheduled Maintenance for three (3) water chillers as described in the Request for Bids during the first year of equipment operation after start-up for the total annual sum of:


The sum will be increased each year thereafter by not more than the annual percentage amount of:
Water Chiller Evaporator and Condenser Water Pressure Drops:

Equipment Supplier agrees to provide water chillers with maximum water pressure drops as stated below:

- Evaporator WPD at 2,000 GPM: __________ feet w.g.
- Condenser WPD at 2,500 GPM: __________ feet w.g.

Water Chiller Evaporator and Condenser Water Flow Rates:

Equipment Supplier agrees to provide water chillers with minimum and maximum flow rates as stated below:

- Minimum Evaporator Flow Rate: __________ GPM
- Maximum Evaporator Flow Rate: __________ GPM
- Minimum Condenser Flow Rate: __________ GPM
- Maximum Condenser Flow Rate: __________ GPM
Water Chiller Efficiency:

Equipment Supplier agrees to provide water chillers with the power requirements indicated below:

**Summer Period:**

<table>
<thead>
<tr>
<th>OSA Temp. (°F)</th>
<th>Load (Tons)</th>
<th>Evaporator</th>
<th>Condenser</th>
<th>Power (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>EWT (°F)</td>
<td>LWT (°F)</td>
<td>Flow (GPM)</td>
</tr>
<tr>
<td>102.5</td>
<td>1,000</td>
<td>54</td>
<td>40</td>
<td>1,714</td>
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<tr>
<td>97.5</td>
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<td>52.5</td>
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<td>740</td>
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<td>0.0001</td>
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<tr>
<td>42.5</td>
<td>870</td>
<td>40</td>
<td>0.0001</td>
<td>55.0</td>
</tr>
</tbody>
</table>

**Winter Period:**

<table>
<thead>
<tr>
<th>OSA Temp. (°F)</th>
<th>Load (Tons)</th>
<th>Evaporator</th>
<th>Condenser</th>
<th>Power (kW)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>EWT (°F)</td>
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<td>72.0</td>
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<tr>
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<td>900</td>
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<td>0.0001</td>
<td>56.6</td>
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<tr>
<td>47.5</td>
<td>740</td>
<td>40</td>
<td>0.0001</td>
<td>55.0</td>
</tr>
<tr>
<td>42.5</td>
<td>870</td>
<td>40</td>
<td>0.0001</td>
<td>55.0</td>
</tr>
</tbody>
</table>

Note: Suppliers are to complete the tables above. Entering evaporator water temperatures are to be 54 deg. F at the stipulated loads unless the calculated evaporator flow at these conditions is below the minimum. If the calculated evaporator flow based upon a 54 deg. F entering evaporator water temperature is below the minimum, the evaporator minimum flow shall be the minimum and the entering evaporator water temperature shall be calculated.
based upon the stipulated load and the stipulated evaporator leaving water temperature. Condenser water flow rates shall be equal to the product of the stipulated load and 2.5 GPM per Ton or the minimum whichever is higher.

Supplier understands that the Owner reserves the right to reject any or all Bids and to waive any formalities in the Bids.

(Seal if by corporation) Respectfully submitted,

__________________________
Business Address

__________________________
Supplier

Date:______________________, 2002

By:________________________

Title:______________________
00400 – PACKAGE “A”
EQUIPMENT PERFORMANCE DATA

Design Conditions:

Each water chiller shall be selected to operate at the conditions listed below:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Capacity (tons)</td>
<td>1,000</td>
</tr>
<tr>
<td>Evaporator Flow (gpm)</td>
<td>2,000</td>
</tr>
<tr>
<td>Evaporator Entering Water Temperature (deg. F.)</td>
<td>54.0</td>
</tr>
<tr>
<td>Evaporator Leaving Water Temperature (deg. F.)</td>
<td>42.0</td>
</tr>
<tr>
<td>Evaporator Maximum Water Pressure Drop (ft.)</td>
<td>30</td>
</tr>
<tr>
<td>Evaporator Fouling Factor (hr. ft² °F/BTU)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Condenser Flow (GPM)</td>
<td>3,000</td>
</tr>
<tr>
<td>Condenser Entering Water Temperature (deg. F.)</td>
<td>85.0</td>
</tr>
<tr>
<td>Condenser Maximum Water Pressure Drop (ft.)</td>
<td>30</td>
</tr>
<tr>
<td>Condenser Fouling Factor (hr. ft² °F/BTU)</td>
<td>0.00025</td>
</tr>
<tr>
<td>Chiller Power (kW)</td>
<td>Supplier to Provide</td>
</tr>
<tr>
<td>Voltage / Phase</td>
<td>480/3</td>
</tr>
</tbody>
</table>

Note: Verification of performance services are to be provided for each water chiller at these conditions only.

Elevated Entering Condenser Water Temperature:

Each water chiller shall be capable of operating at the conditions listed below:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Capacity (tons)</td>
<td>Supplier to Provide</td>
</tr>
<tr>
<td>Evaporator Flow (gpm)</td>
<td>Supplier to Provide</td>
</tr>
<tr>
<td>Evaporator Entering Water Temperature (deg. F.)</td>
<td>54.0</td>
</tr>
<tr>
<td>Evaporator Leaving Water Temperature (deg. F.)</td>
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</tr>
<tr>
<td>Evaporator Fouling Factor (hr. ft² °F/BTU)</td>
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</tr>
<tr>
<td>Condenser Flow (GPM)</td>
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</tr>
<tr>
<td>Condenser Entering Water Temperature (deg. F.)</td>
<td>88.0</td>
</tr>
<tr>
<td>Condenser Fouling Factor (hr. ft² °F/BTU)</td>
<td>0.00025</td>
</tr>
<tr>
<td>Chiller Power (kW)</td>
<td>Supplier to Provide</td>
</tr>
<tr>
<td>Voltage / Phase</td>
<td>480/3</td>
</tr>
</tbody>
</table>
Constant Condenser Water Temperature Unloading:

Each water chiller shall be capable of operating at the conditions listed below:

<table>
<thead>
<tr>
<th>Nominal Capacity (tons)</th>
<th>400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaporator Flow (gpm)</td>
<td>Supplier to Provide</td>
</tr>
<tr>
<td>Evaporator Entering Water Temperature (deg. F.)</td>
<td>Supplier to Provide</td>
</tr>
<tr>
<td>Evaporator Leaving Water Temperature (deg. F.)</td>
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</tr>
<tr>
<td>Evaporator Fouling Factor (hr. ft² °F/BTU)</td>
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</tr>
<tr>
<td>Condenser Flow (GPM)</td>
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</tr>
<tr>
<td>Condenser Entering Water Temperature (deg. F.)</td>
<td>85.0</td>
</tr>
<tr>
<td>Condenser Fouling Factor (hr. ft² °F/BTU)</td>
<td>0.00025</td>
</tr>
<tr>
<td>Chiller Power (kW)</td>
<td>Supplier to Provide</td>
</tr>
<tr>
<td>Voltage / Phase</td>
<td>480/3</td>
</tr>
</tbody>
</table>

Note: Evaporator flow at this condition shall be 800 GPM or the minimum whichever is higher.

Reduced Evaporator Leaving Water Temperature:

Each water chiller shall be capable of operating at the conditions listed below:

<table>
<thead>
<tr>
<th>Nominal Capacity (tons)</th>
<th>Supplier to Provide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaporator Flow (gpm)</td>
<td>Supplier to Provide</td>
</tr>
<tr>
<td>Evaporator Entering Water Temperature (deg. F.)</td>
<td>54.0</td>
</tr>
<tr>
<td>Evaporator Leaving Water Temperature (deg. F.)</td>
<td>38.0</td>
</tr>
<tr>
<td>Evaporator Fouling Factor (hr. ft² °F/BTU)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Condenser Flow (GPM)</td>
<td>3,000</td>
</tr>
<tr>
<td>Condenser Entering Water Temperature (deg. F.)</td>
<td>85.0</td>
</tr>
<tr>
<td>Condenser Fouling Factor (hr. ft² °F/BTU)</td>
<td>0.00025</td>
</tr>
<tr>
<td>Chiller Power (kW)</td>
<td>Supplier to Provide</td>
</tr>
<tr>
<td>Voltage / Phase</td>
<td>480/3</td>
</tr>
</tbody>
</table>
### Design Conditions:

Each water chiller shall be selected to operate at the conditions listed below:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Capacity (tons)</td>
<td>1,000</td>
</tr>
<tr>
<td>Evaporator Flow (gpm)</td>
<td>2,000</td>
</tr>
<tr>
<td>Evaporator Entering Water Temperature (deg. F.)</td>
<td>54.0</td>
</tr>
<tr>
<td>Evaporator Leaving Water Temperature (deg. F.)</td>
<td>42.0</td>
</tr>
<tr>
<td>Evaporator Fouling Factor (hr. ft² °F/BTU)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Condenser Flow (GPM)</td>
<td>2,500</td>
</tr>
<tr>
<td>Condenser Entering Water Temperature (deg. F.)</td>
<td>85.0</td>
</tr>
<tr>
<td>Condenser Fouling Factor (hr. ft² °F/BTU)</td>
<td>0.00025</td>
</tr>
<tr>
<td>Chiller Power (kW)</td>
<td>Supplier to Provide</td>
</tr>
<tr>
<td>Voltage / Phase</td>
<td>480/3</td>
</tr>
</tbody>
</table>

Note: Verification of performance services are to be provided for each water chiller at these conditions only.

### Elevated Entering Condenser Water Temperature:

Each water chiller shall be capable of operating at the conditions listed below:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Capacity (tons)</td>
<td>Supplier to Provide</td>
</tr>
<tr>
<td>Evaporator Flow (gpm)</td>
<td>Supplier to Provide</td>
</tr>
<tr>
<td>Evaporator Entering Water Temperature (deg. F.)</td>
<td>54.0</td>
</tr>
<tr>
<td>Evaporator Leaving Water Temperature (deg. F.)</td>
<td>42.0</td>
</tr>
<tr>
<td>Evaporator Fouling Factor (hr. ft² °F/BTU)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Condenser Flow (GPM)</td>
<td>2,500</td>
</tr>
<tr>
<td>Condenser Entering Water Temperature (deg. F.)</td>
<td>88.0</td>
</tr>
<tr>
<td>Condenser Fouling Factor (hr. ft² °F/BTU)</td>
<td>0.00025</td>
</tr>
<tr>
<td>Chiller Power (kW)</td>
<td>Supplier to Provide</td>
</tr>
<tr>
<td>Voltage / Phase</td>
<td>480/3</td>
</tr>
</tbody>
</table>
**Constant Condenser Water Temperature Unloading:**

Each water chiller shall be capable of operating at the conditions listed below:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Capacity (tons)</td>
<td>400</td>
</tr>
<tr>
<td>Evaporator Flow (gpm)</td>
<td>Supplier to Provide</td>
</tr>
<tr>
<td>Evaporator Entering Water Temperature (deg. F.)</td>
<td>Supplier to Provide</td>
</tr>
<tr>
<td>Evaporator Leaving Water Temperature (deg. F.)</td>
<td>42.0</td>
</tr>
<tr>
<td>Evaporator Fouling Factor (hr. ft² °F/BTU)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Condenser Flow (GPM)</td>
<td>2,500</td>
</tr>
<tr>
<td>Condenser Entering Water Temperature (deg. F.)</td>
<td>85.0</td>
</tr>
<tr>
<td>Condenser Fouling Factor (hr. ft² °F/BTU)</td>
<td>0.00025</td>
</tr>
<tr>
<td>Chiller Power (kW)</td>
<td>Supplier to Provide</td>
</tr>
<tr>
<td>Voltage / Phase</td>
<td>480/3</td>
</tr>
</tbody>
</table>

Note: Evaporator flow at this condition shall be 800 GPM or the minimum whichever is higher.

**Reduced Evaporator Leaving Water Temperature:**

Each water chiller shall be capable of operating at the conditions listed below:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Capacity (tons)</td>
<td>Supplier to Provide</td>
</tr>
<tr>
<td>Evaporator Flow (gpm)</td>
<td>Supplier to Provide</td>
</tr>
<tr>
<td>Evaporator Entering Water Temperature (deg. F.)</td>
<td>54.0</td>
</tr>
<tr>
<td>Evaporator Leaving Water Temperature (deg. F.)</td>
<td>38.0</td>
</tr>
<tr>
<td>Evaporator Fouling Factor (hr. ft² °F/BTU)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Condenser Flow (GPM)</td>
<td>2,500</td>
</tr>
<tr>
<td>Condenser Entering Water Temperature (deg. F.)</td>
<td>85.0</td>
</tr>
<tr>
<td>Condenser Fouling Factor (hr. ft² °F/BTU)</td>
<td>0.00025</td>
</tr>
<tr>
<td>Chiller Power (kW)</td>
<td>Supplier to Provide</td>
</tr>
<tr>
<td>Voltage / Phase</td>
<td>480/3</td>
</tr>
</tbody>
</table>
PART 1 - GENERAL

1.01 QUALITY ASSURANCE:
   A. Experience: At the time of submission of the Bid, the chiller model must have been in standard production for a minimum of one year.
   B. Air-Conditioning and Refrigeration Institute (ARI): Chiller performance shall be rated in accordance with ARI 550/590-98.
   C. Air-Conditioning and Refrigeration Institute (ARI): Chiller sound pressure level shall be rated in accordance with ARI 575-87. The “A” weighted scale shall be measured at a distance of 1 meter from the chillers.
   E. American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE): Construct chillers in accordance with ASHRAE 34, "Number Designation and Safety Classification of Refrigerants".
   F. ASME Section VIII: Construct chillers in accordance with the “Boiler and Pressure Vessel Code”.
   G. National Electrical Manufacturers Association (NEMA): Provide motor for chillers, which is in compliance with NEMA MGI, "Motors and Generators".
   H. Underwriters Laboratories, Inc. (UL): Provide chillers which are UL listed and has UL label affixed indicating UL 465, "Central Cooling Air Conditioners".

1.02 DELIVERY, STORAGE AND HANDLING: Coordinate delivery, storage, and handling with the Contractor. Refer to Section 00200 - General Conditions.

1.03 ANTICIPATED OPERATING CONDITIONS FOR WATER CHILLERS: The water chillers shall be capable of operating at varying evaporator flow rates (1250 GPM minimum to 2,200 GPM maximum), varying evaporator entering water temperatures (48 degrees F minimum to 58 degrees F maximum), varying evaporator leaving water temperatures (38 degrees F minimum to 46 degrees F maximum), varying condenser water flow rates (1,750 GPM minimum to 3,000 GPM maximum), and varying entering condenser water temperatures (55 degrees F minimum to 88 degrees F maximum). Entering condenser water temperatures as low as 40 degrees F may be experienced at start-up.

1.04 PERFORMANCE DATA: Performance data for each set of defined operating conditions (refer to Section 00400 and 00410 - Equipment Performance Data for Water Chillers shall be provided with each Bid. Performance data shall include evaporator flow rate, minimum and maximum evaporator flow rate, evaporator entering water temperature, evaporator leaving water temperature, evaporator
fouling factor, evaporator water pressure drop, condenser flow rate, condenser entering water temperature, condenser leaving water temperature, condenser fouling factor, condenser water pressure drop, sound pressure level (dBA), motor voltage, motor current (RLA), and motor power requirement (kW). Water chillers shall be capable of operating in a stable manner for a sustained period of time under each set of defined operating conditions.

1.05 PHYSICAL DESCRIPTION: A physical description of each water chiller shall be provided with each Bid. The physical description shall include the following information:

A. Detailed drawings of the proposed equipment (including the remote starter or VFD if applicable) including a top view, right side view, left side view, and front view. The drawings shall indicate the dimension of the unit, locations of all connections (chilled water, tower water, electrical controls, refrigerant relief, purge, etc.), and service clearances. The drawings shall also indicate the type and size of each piping connection.

B. Detailed electrical wiring diagram that indicates all required field wiring and components including power and controls.

C. Detailed shipping instructions including shipping weights, operating weights, and rigging instructions.

D. Detailed installation instructions that address all installation requirements including refrigerant charge, wire sizes, refrigerant purge piping, refrigerant relief piping, anchors, mounting of sensors, etc.).

E. Product data indicating impeller speed (RPM), motor speed (RPM), type of motor (open or hermetic), number of bearings, type of bearings, number of compressor stages, number of sets of inlet guide vanes, amount of refrigerant charge (lbs.), and amount of oil required (lbs.).

F. Other information required to verify compliance with the Request for Bids.

1.06 SCHEDULED MAINTENANCE REQUIREMENTS: A complete list of the recommended scheduled maintenance requirements for each water chiller shall be provided with each Bid. The list shall identify each recommended service item and its recommended frequency (monthly, quarterly, etc.)

1.07 SERVICE ORGANIZATION: A complete description of the Service Organization that will provide installation and start-up assistance, first year warranty, Extended Warranty (if the Extended Warranty price is accepted by the Owner), scheduled maintenance (if the scheduled maintenance Bid is accepted by the Owner) for the proposed equipment shall be provided with each Bid. The service organization shall be a direct branch of the chiller manufacturer. The description shall include the name, location (city and state), and street address for the service organization. The description shall also include the number of service organization employees that have been trained and factory certified to service the proposed equipment, number of water chillers currently being serviced, and the amount of floor space at the local facility that is designated for the storage of water chiller spare parts.

1.08 REFERENCES: A complete list of references for each type of water chiller shall be provided with each Bid. The list shall include a minimum of five (5) references where equipment of similar manufacturer type, capacity, and refrigerant has been
installed. The list shall indicate the name of the facility where the equipment has been installed, location (city and state) of the equipment, installation date, equipment capacity (tons), contact name, and contact telephone number for each reference.

1.09 FIRST YEAR WARRANTY: Provide a complete equipment warranty on all parts (including variable frequency drives if applicable), material, labor, refrigerant, and oil for one (1) year after the applicable date of Project Acceptance. The supplier shall provide on site warranty service within four (4) hours after the initial call for service. The cost of the first year warranty shall be included in the amount indicated for the line item designated “Equipment Price” on the Bid Form.

1.10 INSTALLATION AND START-UP ASSISTANCE: Supplier shall provide installation and start-up assistance to the Contractor. Such assistance shall be provided by a factory trained and certified technician. The date of the installation and start-up assistance provided by the Supplier shall be coordinated with the Contractor and the Owner. Service representative shall inspect the equipment installation and verify that the installation is in accordance with factory recommendations. Service representative shall verify that the power wiring, control wiring, piping connections, flow rates, and temperatures are correct prior to starting the equipment. The service representative shall thoroughly document the conditions at start-up in a detailed report. The service representative shall submit eight (8) copies of the report to the Contractor for processing and review by the Engineer and Owner. The cost of the installation and start-up assistance shall be included in the amount indicated for the line item designated “Equipment Price” on the Bid Form.

1.11 VERIFICATION OF PERFORMANCE PRICE: Supplier shall provide a price to provide verification of equipment performance (refer to Section 00600 – Verification of Performance Specifications additional information). The cost of the verification process shall be indicated on the Bid Form on the line item designated “Verification of Equipment Performance Data Price”.

1.12 EXTENDED WARRANTY PRICE: Supplier shall provide a price to provide a four (4) year extension of the first year equipment warranty (refer to Section 00900 – Extended Warranty Specifications for additional information). The cost of the four (4) year warranty extension shall be indicated on the Bid Form on the line item designated “Extended Warranty Bid”.

1.13 SCHEDULED MAINTENANCE PRICE: Supplier shall submit a price to provide scheduled maintenance services (refer to Section 00700 – Scheduled Maintenance Specifications for additional information). The cost of the scheduled maintenance services and the maximum allowable annual percentage increase in the cost of scheduled maintenance services shall be indicated on the Bid Form in the appropriate locations on the line item designated “Scheduled Maintenance Price”.

1.14 SUBMITTALS: After receipt of a Purchase Order, the Supplier shall submit eight (8) copies of submittal documents to the Contractor. Each set of submittal documents shall be bound together in 3-ring binder. The binder shall be clearly marked to indicate the name of the project, Owner, Contractor, Engineer, and Supplier. The information shall be organized into sections. Each section shall be tabbed and labeled. Each set of submittal documents shall include the information listed below:
A. **Physical Description:** Refer to Paragraph 1.05 above for required information.

B. **Performance Data:** Refer to Paragraph 1.04 for required information.

C. **Operation and Maintenance Manuals:** Manuals shall include operating instructions, maintenance instructions, troubleshooting information, parts lists, and other related information.

## PART 2- PRODUCTS

### 2.01 ACCEPTABLE MANUFACTURERS:

A. Carrier

B. York

C. Trane.

### 2.02 REFRIGERANT:

Refrigerant shall be HCFC-123 or HFC-134a.

### 2.03 PAINT:

Water chiller surfaces shall be painted with one coat of corrosion inhibiting latex primer paint and one coat of acrylic enamel paint.

### 2.04 SHIPMENT:

Water chillers shall be shipped as a complete assembly (FOB site) to the site. Refrigerant shall either be shipped to the site in the unit or shipped separately (FOB site). If refrigerant is shipped separately to the site, the water chiller shall be shipped with a nitrogen holding charge.

### 2.05 DIMENSIONS:

A. The dimensions of each water chiller shall not exceed 10'-3" wide by 11'-0" tall by 18'-10" long (including nozzles).

### 2.06 ISOLATION PADS:

Chillers shall be furnished with neoprene isolation pads.

### 2.07 COMPRESSOR:

A. The compressor shall be of the centrifugal type with single or multiple stages.

B. Compressor may include hot gas bypass. If hot gas bypass is used, the Supplier shall indicate the evaporator flow rate at which the hot gas bypass will be activated at a constant entering condenser water temperature of 85 deg. F.

C. Compressor shall be equipped with inlet guide vanes at the inlet of the impeller.

D. Compressor assembly shall be run tested at the factory. Testing shall include vibration levels and impeller over-speed. The results of such testing shall be recorded in a report format and submitted to the Engineer for review and approval.

E. Compressor assembly vibration shall not exceed 0.15 inches per second.

F. Compressor impeller shall be dynamically balanced and over-speed tested at a minimum of 120% of the design impeller shaft speed.

G. Impeller shall be fully shrouded and made of a high strength alloy.
H. Compressor drive may be either direct or gear driven. Transmission gears (if used) shall conform to AGMA Standards, Quality II.

I. Compressor shall be provided with a factory installed lubrication system to deliver oil under pressure to bearings and transmission (if applicable). Lubrication system shall include oil pump, oil cooler, oil heater, oil pressure regulator, oil filter with isolation valves, oil sump heater, and oil temperature sensor.

2.08 MOTOR:
A. The motor may be either open or hermetic. Motor windings shall be copper.
B. If an open drive is provided, the chillers shall be equipped with a shaft seal leakage containment system.
C. Full load operation of the motor shall not exceed the nameplate rating. Motor service factor shall be limited to 1.0.

2.09 PURGE SYSTEM:
A. The manufacturers of low-pressure machines must provide a separate compressor type purge system. Acceptable purges are the Trane Purifier Purge and the York Skyguard Purge. The York Turbo-Guard purge is acceptable if a chiller pressure control system is installed on the chillers. The chiller pressure control system shall be fully automatic and control the pressure in the chillers to 0 PSIG ± 0.1 PSI during the off cycle. It shall be capable of pressurizing the chillers to 10 PSIG for leak testing. Control module shall be solid state with an electric resistance heater applied to the chillers evaporator under the evaporator insulation. The system shall have safety logic to prevent raising chillers pressure to a level that presents a risk of release of part or all the chillers refrigerant charge to the atmosphere. No other purge will be considered.
B. Any excess purge requirement will enable an alarm indication light at each chiller unit control panel, a contact closure at the purge shall be provided for remote alarm annunciation, and a diagnostic (with date and time of occurrence) shall be stored in the chiller unit control panel’s diagnostic summary.

2.10 REFRIGERANT MONITOR:
A. Each chiller shall be finished with a refrigerant monitor and refrigerant sensor. The use of a single monitor with three (3) sensors will be acceptable. The refrigerant monitors and sensors shall be shipped separately from the water chillers. The Contractor shall install the refrigerant monitors and sensors.
B. Acceptable Models:
   1. Trane Model RMWC.
   2. Mine Safety Appliances, Model "Chillgard IR".
   3. Sherlock Model 204 with 82-101 CMOS sensors.
C. Alternate Monitors:
1. Alternate sensors shall be approved prior to submission of Bids.
2. Monitor shall be compound specific with a measurement and display range 0-1000 ppm.
3. The monitor must be calibrated for the specified refrigerant.
4. The display accuracy shall be +/- 1 ppm.
5. Three factory-set alarm levels shall be provided each with a front panel light and a latching binary contact closure for the control of remote devices.
6. An analog output corresponding to the unit display is required for connection to an EMS system (not the chiller control panel).
7. Ambient temperature operating range shall be 40 to 105 F.
8. Must be UL 2075 listed.

2.11 EVAPORATOR AND CONDENSER:
A. The evaporator and condenser shall be built in accordance with BSR/ASHRAE 15-1992, "Safety Code for Mechanical Refrigeration".
B. Water piping connections shall be flanged or plain end, capable of welding flanges in the field.
C. Evaporator and condenser shall be shell and tube type heat exchangers with copper tubing, steel shells, and steel shell ends with nozzle connections.
D. Tubes shall be rolled into tube sheets and shall be individually replaceable. Minimum tube thickness shall be 0.028 inches, including internally enhanced tubes.
E. Evaporator and condenser tubes may be smooth or internally or externally enhanced.
F. Supply and return water connections shall be designed for a minimum working pressure of 150 psig. Shells shall be subjected to a factory hydrostatic pressure test of 225 psig.
G. Water chillers shall be furnished with evaporator and condenser differential pressure switches. Differential pressure switches shall have a pressure rating of 150 psig. Differential pressure switches shall be installed by the Contractor in the external chilled water and tower water piping.
H. Furnish factory installed refrigerant relief valves.

2.12 REFRIGERANT ISOLATION VALVES: Chillers that utilize HFC-134a refrigerant shall be equipped with refrigerant isolation valves such that the entire refrigerant charge can be transferred to the condenser and stored.

2.13 FACTORY INSULATION:
A. All low temperature surfaces including the evaporator, evaporator water boxes, economizer (if applicable), motor cooling lines (if applicable), and suction elbow of the each water chiller shall be insulated at the factory. If factory insulation is not provided, the Supplier shall insulate the low temperature surfaces of the water chiller on site.
B. Insulation shall be of the closed cell foam type (0.28 BTU/hr-SF-deg. F). Insulation shall be a minimum of ¾” thick (economizer insulation if applicable may be 3/8” thick).

2.14 CONTROLS:

A. General: Chillers shall be equipped with an independent direct digital control system. Control system shall include a microprocessor based control panel. Control panel shall provide for chiller operation and monitoring.

B. Wiring: Control panel wiring shall be color-coded. Wiring connections to the control panel shall be made at numbered terminal blocks.

C. Memory: Water chiller set-up and control information shall be stored in non-volatile memory.

D. Password Protection: Control panel functions shall be password protected.

E. Chilled Water Temperature Control: Control panel shall provide for the automatic loading and unloading of the chiller as required to maintain the leaving chilled water temperature at setpoint. Setpoint shall be locally (at the control panel) and remotely (through the SW Plant EMS) adjustable.

F. Current Limit Control: Control panel shall automatically limit chiller loading as required to prevent the motor current from exceeding the setpoint. Setpoint shall be locally (at the control panel) and remotely (through the campus EMS) adjustable.

G. Safeties: Control panel shall provide for safe and automatic shutdown in under the following conditions: low chilled water temperature, low evaporator refrigerant temperature, high condenser refrigerant pressure, evaporator and condenser water flow status, low oil pressure, low oil temperature, high oil temperature, high motor winding temperatures, high motor bearing oil temperatures, sensor faults, starter faults, and improper operation of unit controls. Chiller internal safety devices shall be of the latching tripout type requiring a manual reset.

H. Bearing Oil Temperatures: Control panel shall monitor motor bearing temperatures (including high speed, low speed, and thrust bearings) using factory installed temperature sensors installed in the oil return lines of each motor bearing. If an oil temperature exceeds a set value, the chiller control panel shall shut down the chiller, display the diagnostic, and light an LED on the front of the control panel.

I. Counters: Control panel shall be equipped with digital run time and starts counters.

J. Display: Control panel display shall be capable of displaying in clear language (without the use of codes) the information listed below:

1. Entering and leaving evaporator and condenser water temperatures.
2. Evaporator, condenser, compressor suction, and compressor discharge refrigerant pressures and temperatures.
3. Evaporator and condenser approach temperatures.
4. Compressor motor voltage, current, kW, and power factor (for each phase).
5. Compressor motor percent RLA.
6. All control, warning, and alarm setpoints.
7. Compressor status, number of starts, and operating hours.
8. Purge status, compressor suction temperature, pumpout rate, number of starts, and operating hours (HCFC-123 only).
9. Chiller diagnostics including a time and date of occurrence (minimum of 20 historical diagnostics stored in non-volatile control panel memory).
10. Motor winding temperatures.
11. Bearing oil temperatures.
12. Oil temperature, tank pressure, pump discharge pressure, and differential pressure.

K. Adaptive Evaporator Temperature Control: Control panel shall provide evaporator freeze protection and low limit control. Control mechanism shall be structured to avoid low evaporator temperature trip-outs during critical periods of chiller operation. Control system shall take progressively more aggressive load limiting action in response to the severity of the rate of change and the actual value of the evaporator refrigerant temperature.

L. Adaptive Condenser Pressure Control: Control panel shall provide high condenser pressure protection and control. Control mechanism shall be structured to avoid high condenser pressure trip-outs during critical periods of chiller operation. Control system shall take progressively more aggressive load limiting action in response to the severity of the rate of change and the actual value of the condenser pressure.

M. Adaptive Surge Protection: Control panel shall be equipped to detect surge operation. Control system shall limit chiller loading through inlet vane modulation as required to avoid surge operation. If the surge condition persists, the chiller shall be automatically shutdown.

N. The chiller shall be equipped for direct interface to the Southwest Plant EMS. Interface shall provide for remote chiller start / stop, general alarm annunciation, leaving water temperature reset and current limit reset. Campus energy management system shall provide for chiller sequencing, chilled water pump starting and stopping, tower water pump starting and stopping, tower water temperature control, entering and leaving tower water temperature, entering and leaving chilled water temperature. In addition to the EMS direct interface, provide means (0-10 volt or 4-20mA) to hardwire chiller start/stop, status (discrete contact closure), current limit, and chilled water reset.

2.15 MOTOR PROTECTION:
A. Motor protection shall either be provided at the starter or the control panel.
B. Motor protection shall safeguard the motor from damage resulting from the events listed below:
1. Phase loss.
2. Phase current or voltage imbalance.
3. Phase reversal.
4. Over voltage.
5. Under voltage.
7. Momentary power loss protection with auto restart.
8. Starter contactor fault.

2.16 STARTER SOLID STARTER:

A. Furnish a reduced-voltage, liquid-cooled or air cooled Solid State Starter, factory-mounted on the centrifugal liquid chilling unit. The starter enclosure shall be NEMA 1 and shall be of modular construction with complete access to all parts without disturbing the refrigerant circuit. Power wiring from the starter to the compressor motor and control wiring from the starter to the chiller control panel shall be completed at the factory or at the site by the service representative of the Supplier. The starter shall be tested and the design starting current and overload settings shall be adjusted at the factory. The starter shall provide, through the use of six silicon-controlled rectifiers (2 per phase), a smooth acceleration of the motor without current transitions or transients.

B. The following protective devices items shall be factory mounted and wired to the starter:

1. 3-leg sensing electronic overloads with indicating lights and reset button shall shut unit down if current exceeds 105% of FLA to protect the motor windings.
2. Phase rotation protection circuit and indicating light shall deny start-up when detecting incorrect power wiring phase sequence to the starter, which could cause reverse motor rotation and damage the equipment.
3. Single-phase failure protection circuit and indicating light shall insure against motor burnout by shutting the unit down if power loss occurs in any of the incoming lines during start up.
4. High temperature safety protection system with indicating light and reset button thermistors embedded on heat sinks shall shut the unit down if the SCR temperature exceeds acceptable limits.
5. Hinged access door with lock and keys shall prevent tampering by unauthorized personnel.
6. High and low line voltage protection.

C. The following items shall be factory mounted and wired to the starter:

1. Control power transformer with over current protection.
2. The 480V power to the oil pump shall be factory wired to the starter. Provide a separate means of disconnecting power to the oil pump for servicing.

3. Digital Elapsed Time Meter shall easily keep track of operating hours to gauge regular maintenance and inspection requirements.

4. Power Fault Protection momentary power interruption protection detects power interruptions within 3/4-line cycle and shall interrupt power to the compressor motor within 4 line cycles.

5. Electrical lugs – tin-plated lugs shall provide easy connection to incoming copper power lines.

6. 3-phase digital ammeter and digital voltmeter readout via control center shall easily cross check design current and voltage limitations against supply characteristics.

2.17 VARIABLE FREQUENCY DRIVES (VFD):

A. Water chillers may be equipped with variable frequency drives. Variable frequency drives may be unit mounted or remote mounted. Variable frequency drives may be either liquid cooled or air cooled. Power and control wiring from the variable frequency drive to the water chiller motor and control panel shall be completed at the factory or at the site by the service representative of the Supplier.

B. The VFD will be specifically designed to interface with the centrifugal water chiller controls and allow for the operating ranges and specific characteristics of the chiller. The VFD control logic shall optimize chiller efficiency by coordinating compressor motor speed and compressor inlet guide vane position to maintain the chilled water setpoint while avoiding surge. If a surge is detected, VFD surge avoidance logic will make adjustments to move away from and avoid surge at similar conditions in the future.

C. The drive efficiency shall be 97% or better at full speed and full load. Fundamental power factor shall be a minimum 0.96 lagging at all speeds and loads.

D. The VFD’s shall each be furnished in a NEMA 1 metal enclosure with three wire input lugs plus a grounding lug for electrical connections, output motor connection via factory installed bus bars and all components properly segregated and completely enclosed in a single metal cabinet. Enclosure shall include a padlockable, door-mounted circuit breaker with shunt trip assembly, tested to a short circuit withstand rating of 65,000 amps per UL 508.

E. The VFD shall be tested to ANSI/UL Standard 508 and shall be listed by a Nationally Recognized Testing Laboratory (NRTL) as designated by OSHA.

F. Ratings of VFD’s shall meet or exceed Electrical Code Table 430-150 for the particular motor it is controlling.

G. Input shall be nominal 480 volts, three phase, 60 Hertz AC power, +/- 10 percent of nominal.
H. VFD’s shall have inherent short circuit protection via main circuit breaker with a minimum short circuit withstand rating of 65,000 amps, and shall be capable of withstanding:

2. Phase to ground short circuit.

I. The drive units shall include the following features:

1. One programmable analog output signal, 0-10 Vdc or 4-20 mA, and three programmable relay outputs for customer use.
2. All control circuit voltages are physically and electrically isolated from power circuit voltage.
3. One hundred fifty percent instantaneous torque available for improved surge control.
4. Minimum and maximum speed adjustments.
5. Soft start, adjustable linear acceleration, coast to stop.
6. Adjustable current limiting and UL approved electronic motor overload protection.
7. Insensitivity to incoming power phase sequence.
8. VFD and motor protection from the following faults:
   a. Phase loss at VFD input.
   b. Grounded phase between the VFD and the motor.
   c. Phase to phase short on VFD output.
   d. Over-voltage, under-voltage, and under-current.
9. Loss of power ride through for a minimum of 20 milliseconds.
10. Cabinet interior overtemperature protection. Cabinet cooling shall be sufficient to allow drives to operate in a continuous 104 F (40 C) room ambient temperature.
11. Protection against DC bus overvoltage.
12. Automatic restart of the inverter after a power outage or power dip. When input power returns to normal following a fault trip for undervoltage or overvoltage, the VFD shall automatically restart if there is a command from the chiller unit control panel. The drive shall not restart after an overload or overcurrent condition.
13. No-load run capability to facilitate start-up and troubleshooting.
14. The VFD shall be capable of starting into a rotating motor.
15. The VFD shall include the following output signals to interface with the control system:
   a. Digital "fault" status
   b. Drive signal indicating VFD amps, input volts, VFD speed.
16. The VFD shall include the following input signals to interface with the control system:
   a. Digital start/stop of drive
   b. Analog speed control by 2-10 Vdc signal corresponding to 0-100% drive speed (with adjustable gain and offset).

17. Automatic operation at minimum speed if the input reference is lost.

18. Acceptable start/stop commands shall include closure of a contact or switch.

19. The drive control shall include a minimum of three programmable critical frequency lockout ranges to prevent the VFD from continuously operating at an unstable speed.

20. The 480V power to the oil pump shall be factory wired to the VFD line terminals. Provide a separate fused disconnect to the oil pump for servicing and over current protection.

21. Digital Elapsed Time Meter shall easily keep track of operating hours to gauge regular maintenance and inspection requirements.

J. The following items shall be displayed on the enclosure door of each drive via a digital keypad:
   1. Motor speed (rpm)
   2. Output motor voltage
   3. DC bus voltage
   4. Drive output motor current
   5. Output frequency (Hz)
   6. Kilowatts (output)
   7. Motor output torque
   8. Y2K compliant elapsed time

K. The following VFD status indicators shall be available to facilitate startup and maintenance:
   1. Running
   2. Remote
   3. Jog
   4. Auto
   5. Forward
   6. Reverse
   7. Program
   8. Password lockout

L. Service Conditions
   1. Room ambient temperature 32-104 F (0-40 C).
2. Room ambient 0-95% relative humidity.
3. Elevation to 3300-feet (1000-meters).
4. AC line voltage variation, -10% to +10% of nominal.
5. Line frequency 38-60 hertz.

M. Warranties
1. The VFD manufacturer shall warrant the variable frequency drive for a period equal to that specified for the chiller. The warranty shall include parts, labor, travel costs, and living expenses incurred by the manufacturer to provide factory-authorized on-site service.

2.18 SCBA DEVICES: Owner furnished and Owner installed.

PART 3 - EXECUTION

3.01 MANUFACTURER RECOMMENDATIONS: The Contractor shall install each water chiller in accordance with the manufacturer's recommendations and the construction documents.

3.02 FOUNDATION: The Contractor shall install each water chiller on a flat concrete pad level to 1/16". The Contractor shall place isolation pads furnished with the chiller under the unit in the proper locations.

3.03 REFRIGERANT RELIEF PIPING: The Contractor shall install refrigerant relief piping from rupture disk to atmosphere in accordance with ASHRAE Standard 15.

3.04 REFRIGERANT PURGE PIPING: The Contractor shall install refrigerant purge piping from purge unit to atmosphere in accordance with ASHRAE Standard 15 (HCFC-123 units only).

3.05 POWER CONNECTIONS: The Contractor shall install power wiring to the starter or VFD. However, the supplier shall include all costs associated with a remote VFD. Costs shall include conductors, raceway, labor and final terminations.

3.06 CONTROL WIRING CONNECTIONS: The Contractor shall install EMS control wiring to the control panel.

3.07 CHILLED WATER PIPING: The Contractor shall install the differential pressure switch furnished with each chiller in the external chilled water piping. The Contractor shall install taps for temperature sensors and gauges in the water piping adjacent to the inlet and outlet evaporator connections. The Contractor shall install drain valves and vent cocks at the evaporator water boxes. The Contractor shall install a strainer at the suction of the chilled water pump.

3.08 TOWER WATER PIPING: The Contractor shall install the differential pressure switch furnished with each chiller in the external tower water piping. The Contractor shall install taps for temperature sensors and gauges in the water piping adjacent to the inlet and outlet condenser connections. The Contractor shall install drain valves and vent cocks at the condenser water boxes. The Contractor shall install a strainer at the suction of the tower water pump. The Contractor shall install a head pressure control valve in the piping at the outlet of the condenser.
3.09 REFRIGERANT MONITOR AND SENSORS: The Contractor shall install the refrigerant monitors and sensors. The Contractor shall provide power wiring and control wiring.
PART 1 - GENERAL

1.01 QUALITY ASSURANCE:
   A. Experience: At the time of submission of the Bid, the harmonic filter model must have been in standard production for a minimum of one year.
   B. IEEE 519: Harmonic filter and its installation shall comply with the requirements and recommendations of IEEE 519.

1.02 DELIVERY, STORAGE AND HANDLING: Coordinate delivery, storage, and handling with the Contractor. Refer to Section 00200 - General Conditions.

1.03 FIRST YEAR WARRANTY: Provide a complete equipment warranty on all parts, material, and labor for one (1) year after the applicable date of Project Acceptance. The supplier shall provide on site warranty service within four (4) hours after the initial call for service. The cost of the first year warranty shall be included in the amount indicated for the line item designated “Harmonic Filter Price” on the Bid Form.

1.04 SUBMITTALS: After receipt of a Purchase Order, the Supplier shall submit eight (8) copies of submittal documents to the Contractor. Each set of submittal documents shall be bound together in 3-ring binder. The binder shall be clearly marked to indicate the name of the project, Owner, Contractor, Engineer, and Supplier. The information shall be organized into sections. Each section shall be tabbed and labeled. Each set of submittal documents shall include the information listed below:
   A. Physical Description: Refer to Paragraph 1.05 above for required information.
   B. Operation and Maintenance Manuals: Manuals shall include operating instructions, maintenance instructions, troubleshooting information, parts lists, and other related information.

PART 2 - PRODUCTS

2.01 HARMONIC FILTERS: Provide a harmonic filter at each variable frequency drive. Filters shall be designed to reduce total harmonic distortion as measured at the line input power connections to the water chiller to less than 5%. Filters may be either unit mounted or remote mounted. Power and control wiring from the harmonic filter to the variable frequency drive and control panel shall be completed at the factory or at the site by the service representative of the Supplier.
PART 3 - EXECUTION

3.01 POWER CONNECTIONS: The Contractor shall install power wiring to the harmonic filter.
PART 1 - GENERAL

1.01 SCOPE OF SERVICES: Performance verification services shall include the measurement of capacity and power requirements at the design operating conditions (refer to Sections 00400 and 00410). Verification of Performance services shall be provided for all three (3) water chillers.

1.02 TEST FACILITY: Equipment performance verification shall be conducted at the factory in an ARI certified test facility.

1.03 QUALITY ASSURANCE: Equipment performance verification shall be conducted in accordance with ASHRAE Standard 550/590-98 requirements (with the exception that no tolerances will be permitted).

PART 2 - PRODUCTS

2.01 INSTRUMENT CALIBRATION: Instrument calibration shall be traceable to the National Institute of Standards and Technology.

PART 3 - EXECUTION

3.01 HEAT BALANCE: Performance verification tests shall be conducted after verifying instrument calibration and accuracy using the heat balance process described in ARI Standard 550/590-98.

3.02 FOULING FACTORS: Performance verification tests shall be conducted with clean evaporator and condenser tubes (0.0000 fouling factors). The leaving chilled water temperature shall be adjusted downward to compensate for the design evaporator fouling condition as described in ARI Standard 550/590-98. The entering condenser water temperature shall be adjusted upward to compensate for the design condenser fouling condition as described in ARI Standard 550/590-98.

3.03 WITNESS: The performance verification process shall be structured to permit the Owner and / or his representative witness the process. The Owner will be notified in writing a minimum of 14 days in advance of the performance verification work. All travel costs and expenses of the Owner and the Engineer will be the responsibility of the Owner.

3.04 REPORT: The Supplier shall document the performance verification process and results in a written report. The Supplier shall submit four (4) copies of the report to the Owner for review and approval.

3.05 CAPACITY DAMAGES: In the event that a water chiller fails to produce the capacity stated in the Supplier’s Bid (no tolerances will be permitted), the Supplier will pay damages in the amount of the product of $2,000 and the Equipment Capacity stated in the Supplier’s Bid in Tons less the Measured Capacity in Tons.

Capacity Damages = $2,000 x (Stated Tons – Measured Tons)
3.06 POWER CONSUMPTION DAMAGES: In the event that a water chiller consumes electrical power in excess of the power requirement stated in the Supplier's Bid (no tolerances will be permitted), the Supplier will pay damages in the amount of the product of $2,000 per kW and the Measured Power Requirement in kW less the product of the Measured Capacity in Tons and the Equipment Efficacy in kW per Ton stated in the Supplier's Bid.

\[
\text{Power Consumption Damages} = 2000 \times (\text{Measured kW} - (\text{Measured Tons} \times \text{Stated kW/Ton}))
\]

3.07 TOTAL DAMAGES: Total Damages shall be the sum of the Capacity Damages and the Power Consumption Damages. The Supplier shall pay damages directly to the Owner. Damages shall be paid to the Owner within ninety (90) calendar days after the delivery of the water chillers.
PART 1 - GENERAL

1.01 BID: The Supplier shall indicate a price on the Bid Form in the designated location a price to provide Scheduled Maintenance Services. The Supplier shall also indicate a maximum annual price escalation rate on the Bid Form in the designated location for the cost of the Scheduled Maintenance Services.

1.02 WORK INCLUDED: Provide scheduled (preventive) maintenance services for each water chiller.

1.03 SCOPE OF SERVICES: Scheduled maintenance shall be performed in accordance with the manufacturer's recommendations and accepted industry standards. Adequate documentation of preventive maintenance programs shall be provided to satisfy all federal, state, and local regulations.

1.04 QUALIFICATIONS OF THE SERVICE ORGANIZATION:

A. The Service Organization shall be a recognized specialist that is active in the field of performing mechanical service on heating, ventilation, air conditioning and refrigeration (HVACR) and control systems.

B. The Service Organization shall have been active in this type of work in the Northwest Arkansas area for a minimum of five (5) years.

C. The Service Organization shall be a direct affiliate of the chiller manufacturer. An independent service organization will not be acceptable.

1.05 SERVICE ORGANIZATION PERSONNEL REQUIREMENTS:

A. Personnel:

1. The Service Organization shall perform all services using qualified and trained personnel.

2. The conduct of the Service Organization and all employees of the Service Organization shall be in accordance with the rules and regulations of the Owner.

3. If requested by the Owner, the Service Organization shall remove any employee that engages in improper conduct, appears unqualified to perform their assigned duties, or has violated established procedures regarding security, conduct or safety.

4. The Service Organization (All) shall warrant that all employees are U.S. citizens or are otherwise legally entitled to accept employment with the Service Organization and perform services under this Agreement. The Service Organization shall pay all wages and all applicable federal, state and local taxes, including FICA, unemployment taxes, etc., arising out of such employment.
5. All employees of the Service Organization shall wear uniforms, which bear the name of the employee and the name of the Service Organization.

6. In the event that the Service Organization become a party to a collective bargaining agreement, no provision in that agreement shall be binding upon the Owner. Any attempt to so bind the Owner shall be deemed to be a material breach of this Agreement. No provision in a collective bargaining agreement shall relieve the Service Organization of its obligations under this Agreement.

7. The Service Organization shall have a sufficient number of experienced and qualified HVACR personnel to fulfill the requirements of this Agreement. The Service Organization shall respond on site to requests for service within four (4) hours after the request for service.

8. Account Representative: The Service Organization shall designate an Account Representative, having supervisory status, who shall be accessible regarding any communication relevant to the Agreement.

1.06 INDEMNIFICATION; LIMITS OF LIABILITY:
A. The Service Organization shall agree to indemnify and hold the Owner harmless from any and all costs, expense, damages, liens, charges, claims, judgments, demands or liabilities whatsoever (including attorney’s fees) arising from the acts or omissions of the Service Organization or its agents or employees.

1.07 INSURANCE:
A. The Service Organization shall obtain, pay for, and maintain the following insurance covering the performance of Services as a minimum:

1. Comprehensive General Liability Insurance covering each occurrence of bodily injury in an amount of not less than one million dollars ($1,000,000) and covering each occurrence of property damage in an amount of not less than one million dollars ($1,000,000). In lieu of providing separate coverage for bodily injury and property damage, as specified above, the Service Organization may provide umbrella coverage with the total limit of one million dollars ($1,000,000) for each occurrence. The Comprehensive General Liability Insurance shall cover the Owner as an additional insured and shall contain endorsements providing coverage for the following:
   a) Personal Injury Liability
   b) Broad Form Property Damage
   c) Blanket Contractual Liability
   d) Products and Completed Liability
   e) Premises-Operations Liability
f) Independent Contractor's Protective Liability, if the Service Organization employs subcontractors to perform portions of the Services.

2. Comprehensive Automobile Liability Insurance for owned, hired, and non-owned motor vehicles, if any, used for the performance of the Services. This insurance shall have the same minimum coverage limits as specified above for Comprehensive General Liability Insurance.

3. Workers' Compensation Insurance, Occupational Disease Insurance, and Disability Benefits Insurance, in accordance with applicable statutory requirements.

4. Employers' Liability Insurance in an amount not less than one hundred thousand dollars ($100,000).

B. Prior to the commencement of the Services on the Owner's premises, the Service Organization shall furnish the Owner with certificates of insurance providing evidence of the coverage and limits of liability required under Paragraph 1.05. These certificates shall state that at least thirty (30) days written notice shall be provided to the Owner prior to any cancellation, expiration, non-renewal, or material change in the insurance coverage that occurs during the life of this Agreement.

C. The Service Organization shall be responsible to the Owner for the amount of any deductible contained in any of the foregoing policies and certificate of insurance.

D. These provisions set forth the minimum amounts and scopes of coverage and are not be construed in any way as a limitation on the Service Organization's liability under this Agreement.

PART 2 - PRODUCTS

2.01 GENERAL:
A. Parts, components, and accessories furnished and installed by the Service Organization shall be new and as manufactured by or recommended by the Original Equipment Manufacturer (OEM).

B. Refrigerants, fluids, oil, etc., furnished and installed by the Service Organization shall be as recommended by the Original Equipment Manufacturer (OEM).

C. The Service Organization shall provide all equipment necessary to maintain the chiller, remove and store refrigerant when necessary.

2.02 SPARE PARTS: The Service Organization shall maintain spare parts, materials, and supplies that are typically required for normal and emergency repairs and maintenance.

2.03 REFRIGERANT REMOVAL AND STORAGE: The Service Organization shall own and maintain refrigerant removal and storage equipment of the type and configuration required to service the Base Equipment. The cost of utilizing this equipment if necessary to provide Scheduled Maintenance services shall be included in the price for Scheduled Maintenance services.
PART 3 - EXECUTION

3.01 REPORTING METHOD AND OWNER INSPECTION:
   A. Inspection: All work done and all materials furnished shall be subject to random and periodic inspection and approval by the Owner so as to ascertain that the services rendered are in accordance with requirements and intentions of the specifications and special provisions.
   B. Reporting Method: The Service Organization shall furnish the Owner one (1) copy of a service check receipt for each unit serviced or repaired and a service checklist bearing the signature of the service personnel and the signature of the Owner’s designated representative certifying receipt of services.

3.02 CLEAN-UP:
   A. The Service Organization shall keep the job site free of debris, litter, refuse, etc., and shall clean all fluids that spill or drip during the progress of the work. The Service Organization shall remove all equipment from the area upon completion of the work.

3.03 SCHEDULED MAINTENANCE REQUIREMENTS:
   A. The Service Organization shall provide scheduled maintenance services in accordance with Section 00800 – Scheduled Maintenance Requirements.
   B. The Service Organization shall provide additional scheduled maintenance services as recommended by the equipment manufacturer.
   C. The Owner shall provide access to building, parking, and the use of utilities. The Owner shall maintain security of the equipment rooms.
00800 – SCHEDULED MAINTENANCE REQUIREMENTS

1. Annual Winter Maintenance: Once each year a thorough preventive maintenance program shall be completed. The program shall include the items of work listed below:
   a) Furnish nitrogen, oil filters, and gaskets as required.
   b) Pressure test as required.
   c) Meg test compressor motor and oil pump motor.
   d) Repair any minor leaks.
   e) Detailed inspection of the purge system.
   f) Thorough cleaning of purge compressor, purge oil separator, purge drum, and purge condensing coil (if applicable).
   g) Change purge oil as required (if applicable).
   h) Inspect and calibrate safety controls.
   i) Inspect and tighten all starter terminals. Inspect contacts for wear.
   j) Inspect and calibrate overloads. Record trip amps and trip times.
   k) Inspect and tighten motor terminals and control panel terminals.
   l) Clean oil strainer. Replace filter and gasket as required.
   m) Inspect and tighten oil heater leads.
   n) Inspect and verify proper operation of vane positioner.
   o) Oil sample and analysis for wear metals, acid content, and moisture.
   p) Change oil as required.
   q) Inspect and brush clean condenser tubes.
   r) Check refrigerant level. Add additional refrigerant as required
   s) Report to operator all deficiencies and corrective actions. Identify deficiencies that have not been corrected.
   t) Provide a written report to Owner.

2. Operating Inspections: The operation of the water chiller is to be inspected monthly. Operating inspections shall include the items of work listed below:
   a) Adjust operating and safety controls. Record settings.
   b) Complete operating log of temperatures, pressures, voltages, and amperages.
   c) Verify proper refrigerant charge and add refrigerant as required.
   d) Change oil in purge vacuum pumps as required (if applicable).
   e) Verify proper operation of purge system (if applicable).
f) Verify proper operation of lubrication system including oil pump and oil pressure regulator.

g) Verify proper operation of motor and starter.

h) Inspect operating log.

i) Report to operator all deficiencies and corrective actions. Identify deficiencies that have not been corrected.

j) Provide a written report to the Owner. Operating log shall be attached.

3. Manufacturer’s Instructions: Perform all preventive maintenance services in strict accordance with the equipment manufacturer.

4. The Service Organization shall provide all equipment necessary to maintain the chiller, remove and store refrigerant when necessary.
1.01 PRICE: Supplier shall indicate on the Bid Form in the designated location a price to extend warranty by up to four (4) additional years to result in a five (5) year period of complete water chiller warranty protection from initial Project Acceptance.

1.02 SCOPE OF SERVICES: Extended Warranty shall cover the entire machine including materials, refrigerant, oil, equipment, parts (including the VFD and Harmonic Filter if applicable), and labor.

1.03 REFRIGERANT REMOVAL AND STORAGE: The Service Organization shall own and maintain refrigerant removal and storage equipment of the type and configuration required to service the Base Equipment. The cost of utilizing this equipment if necessary to provide Extended Warranty services shall be included in the price for Extended Warranty services.

1.04 AGREEMENT: Extended Warranty Agreement shall be between the Owner and the equipment manufacturer.

1.05 RESPONSE TIME: The Supplier shall provide on-site warranty service within 4 hours of the initial call for warranty.
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<td>AIR COMINUITION</td>
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## Air Handling Unit (2 of 2)

### Fan Section

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### Mepdivision X-X

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### Sound Power Levels (Casing inlet and outlet)

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### Remarks

SPECIFIED IN SECTION 15600
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**Air Pressure Drop**

- Supply Air Filter: 0.125 in PPI (11.25 in², 2.89 cm²)
- Return Air Filter: 0.125 in PPI (11.25 in², 2.89 cm²)
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* DIFFERENT IN STATIC PRESSURE FROM INLET TO DISCHARGE AT MAXIMUM EXHAUST AIRFLOW
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1 TOTAL AIR FLOW PER UNIT AT MAXIMUM UNIT AIR FLOW.
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**Notes:**
- All dimensions are in inches.
- Weights are in pounds.
- Type refers to the material type used for each piece.

**Date:** 07/25/06

**University of Arkansas at Fayetteville**

**Design Guide Details**
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University of Arkansas at Fayetteville
Design Guide Details

Det 8
Sheet 1 of 1
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<th>Remarks</th>
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**Remarks:**
- Dynamic pressure loss ratings are for 0.75" PPM.
- Pressure drop loss ratings are for 250 fpm.
- Pressure drop loss ratings are for 500 fpm.
- Double wall.
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<th>HEIGHT (in.)</th>
<th>DEPTH (in.)</th>
<th>MAXIMUM AIR FLOW (CFM)</th>
<th>PRESSURE DROP (IN. WATER)</th>
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- Furnish with valve package and PSC motor
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**Notes:**
- Furnish with valve package and 1 HP motor.
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Specified in Section 5.6.0.
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*Furnish 15 hp. cast iron receiver; mechanical alternator, built-in strainer; lubricator, gauge glass, motor starter switch, built-in strainer pump discharge valve, control panel with circuit breakers, motor starters and 460-volt relay.*
### GAS FIRED DOMESTIC WATER HEATERS

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<th>MAX. GAS VOLUME (CFH)</th>
<th>MAX. WATER VOLUME (GAL)</th>
<th>EFF ICY (%)</th>
<th>RECOVERY RATE (GPM)</th>
<th>FUSE TYPE</th>
<th>FAN TYPE</th>
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**NOTE:** RECOVERY RATE BASED ON 10 DEGREE RISE
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Note: Recovery rate based on 40 degree rise
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**NOTE:** Recovery rate based on 90 degree drop.
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*Furnish with OSMA bonded and spare seal*

*Furnish with integral float and power cord*
# Air Separators

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*Specified in Section 19400*

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**University of Arkansas at Fayetteville**

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<th>Rotation</th>
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<th>HP</th>
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<td>648D 1070-5</td>
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<td>BOILER B-1</td>
<td>DOUBLE MAGNUM</td>
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<td>.25</td>
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<td>480/3</td>
<td>PARVUM IN 5 SACL CAST IRON REVERSE MECHANICAL ALTERNATIVE WILK ENGLAND MILLER MAGNUM MAGNUM. WILK STAINLESS TUBE EXCHANGE VALVES, CONTROL PANEL, LITCUP BREAKERS, MOTOR STARTERS AND NOX SWITCHES.</td>
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<td>Material (in.)</td>
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<td>FT-1</td>
<td>FLASH TANKS</td>
<td>VEGABAY</td>
<td>F - 205 X</td>
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<td>5</td>
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*Refer to detail for fitting connections.*
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<td><strong>Equipment</strong></td>
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University of Arkansas at Fayetteville
Design Guide Details
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<tr>
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<th>CAPACITY (LBS/H)</th>
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<th>VALVE SIZE (IN.)</th>
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<td>INLET STEAM PRESSURE (PSIG)</td>
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<td>VALVE SIZE (IN)</td>
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**Pressure Reducing Stations**

Specified in Section 15/00
### Pressure Relief Valves

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<th>Capacity (LBS/MIN)</th>
<th>Capacity (MBH)</th>
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<th>Pressure Relief Setting (PSI)</th>
<th>Valve Size (In.)</th>
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<tr>
<td>RV-1</td>
<td>Kunkle 137</td>
<td>HPS</td>
<td>-</td>
<td>3154</td>
<td>-</td>
<td>125</td>
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</table>
PACO Type LF Frame Mounted, single stage, end suction centrifugal pumps are designed and built for compactness, high performance, durability, and versatility of application.

PACO Frame Mounted pumps with their heavy frames, shafts and ball bearings are ideal for reliable heavy duty service. They are available in 6 different frame sizes to match HP requirements up to 300 HP.

Frame Mounted models feature flexible coupled drive and are available with steel or cast iron bases with drip–lip and drain tapping.

The back pull out feature allows maintenance without disconnecting system piping.

#### Rotation Options
- Clockwise

#### Base/Stand Type
- Steel Base

#### Drip Pan
- Provided

#### Coupling Options
- Woods

#### Bearing Options
- Sealed for life

#### Connections
- 125# ANSI

#### Wear Ring Type
- Case Wear Ring

#### Pump Coatings
- Standard Paint

#### NSF−50 Certification
- Not Required

#### NSF−61 Certification
- Not Required

#### Casing
- Cast Iron, ASTM−A48, CL 30

#### Casing Materials
- Sealed for life
- Sleeve Material: Bronze, III932, C89835
- Wear Ring Material: NiAl–Bronze, ASTM–B148, C95500
- Packing Gland: Not Applicable
- Lantern Ring: None
- Type 21
- Ceramic/Carbon/Buna
- Buna N
- No External flush
- None
- Veg. Fiber
- Steel, AISI 1045
- Casing Bolts
- S.S., AISI–303

---

Project: U A F End Suction Sample  
Location: Fayetteville, AR  
Contractor:  
Engineer: T. M. E.  
Model: 4012A  
Rotation: Clockwise  
Qty: 1  
Service: Water  
P.O. #:  
Cust Ref #:  
By: James Dayer  
Date: 8/15/2006  
Agent/Rep: Fluid Solutions, Inc.  
Rev. #:  
Doc #:  

Units PED FRAME DISCH SUCT C CP D HA HB HD HE HF HG HH HP HT MU N Q U X Y Z # Weight  
inches 6L 254T 4 5 27.0 25.7 8.00 22.00 52.00 12.38 9.50 50.00 0.38 0.625 8.56 1.00 0.88 4.38 5.06 1.375 10.00 5.25 8.38 4 853  

Conditions of Service  
Flow: 500 USgpm  
Temp: 68.00 deg F  
TDH: 75.0 ft  
Fluid: Water  
RPM: 1750  
Eff:  
HP: 15  
Hz: 60  
Phase: Three phase  
Voltage: 208–230/460  
Encl.: ODP  
S.F.: 1.15  

LF – 4012A Configured Curve

By: James Dayer
Date: 8/15/2006
Rev. #

Project: U A F End Suction Sample
Tag #: P−1
P.O. #

Location: Fayetteville, AR
Model: 4012A
Cust Ref#

Contractor: Fluid Solutions, Inc.
Qty: 1
Agent/Rep: Fluid Solutions, Inc.

Engineer: T. M. E.
Service: Water
Doc #

Design Data

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<td>Shutoff Head: 87.4 ft</td>
<td>S.G.: 0.998</td>
<td>Diff. Press:</td>
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<td>NPSHr: 15.57 ft</td>
<td>Visc.: 1.00 cP</td>
<td>BHP: 11.1 hp</td>
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<td>Imp. Dia.: 9.41 in</td>
<td>Pump Eff.: 85.04</td>
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<td>No Of Stages: 1</td>
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Motor Data

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<tr>
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<tr>
<td>Actual RPM: 1750</td>
<td>Hz: 60</td>
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</table>
PART 1 – GENERAL

1.1 SCOPE
A. Types of pumps specified in this section include:

   1. Frame Mounted End Suction

1.2 RELATED WORK:

A. Pumps furnished as part of factory-fabricated equipment are specified as part of the equipment assembly in other Division 15 sections.

B. Motor starters, disconnects, and wiring of pump motors; Division 16

C. Insulation of pump housings; Section 15250

D. Sump pumps; Section 15450

E. Pump system balancing; Section 15980

F. Variable frequency drives; Section 15950

1.3 QUALITY ASSURANCE:

A. Manufacturers: Firms regularly engaged in manufacture of pumps of types and sizes required, whose products have been in satisfactory use in similar service for not less that five (5) years.

B. Provide electric motors and products which have been listed and labeled by Underwriters Laboratories and comply with NEMA standards.

1.4 SUBMITTALS:

A. Product Data: Submit manufacturers pump specifications, installation and start-up instructions, and current accurate pump characteristic performance curves with selection points clearly indicated.

B. Shop Drawings: Submit equipment connection and support details. Equipment connection details to indicate all piping connections with sizes and types of pipe, valves, fittings, specialties, and meter and gauges to be used. Support details to include fabricated, materials, and methods of support intended. Include detail of vibration isolation.

C. Operation and Maintenance Manual: Include maintenance data and spare parts lists for each type of pump.
PART 2 – PRODUCTS

2.1 GENERAL

A. Provide factory-tested pumps, thoroughly cleaned, and painted with one coat of machinery enamel prior to shipment. Type, size and capacity of each pump are listed in pump schedule.

2.2 END SUCTION PUMPS

A. Furnish and install, as outlined on the equipment schedule and described in these specifications, a Paco model LF frame mounted pump, or equal, designed to deliver the scheduled flow rate (in GPM), the specified total dynamic head (in feet), at the scheduled efficiency and scheduled speed (RPM).

B. Pumps shall meet or exceed the efficiency shown in the pump schedule.

C. To insure cavitation-free operation, each pump’s NPSH Requirement must be low enough to permit stable, continuous operation at 120% or greater of best efficiency point.

D. Each pump shall be capable of continuous operation without producing noise in excess of the Hydraulic Institute and OSHA guidelines.

E. Pump casing shall be close grain cast iron fitted with a replaceable (lead-free, bronze, cast iron) case wear ring. Pumps with a specific speed greater than 1600 shall have double-volute casings with suction splitter to reduce radial loading and shaft deflection. All pumps shall be of the back pullout design so that the rotating element can be removed from the casing without disconnecting the suction or discharge piping.

F. Pump impeller shall be of the enclosed type of cast lead-free, bronze and shall be statically and dynamically balanced. Impeller diameter shall be trimmed for the specific design conditions.

G. The pump shaft shall be fitted with a leakless mechanical seal suitable for the temperatures and pressures indicated.

H. Motor shall be of the horsepower and speed shown in the pump schedule. Pumps requiring larger horsepowers shall not be acceptable. Pump shall be (flexible, close) coupled to a (3, 1) phase, (60, 80) Hertz, ______ volt, (horizontal, vertical), (ODP, TEFC, Explosion Proof) motor with (1.15, 1.0) service factor. 40 degree C ambient.

I. All pumps shall be supplied on a base having a drip pan with drain connection.
2.3 BEARING FRAME MOUNTED (LF)

A. Pump shall be mounted on a heavy-duty cast-in-one-piece cast iron bearing frame. Shaft shall be of carbon steel. Pump bearings shall be permanently sealed.

B. Pump and motor shall be mounted on a channel steel base, adequately reinforced against deflection. Pump shall be connected to the drive motor by a flexible coupling capable of withstanding all torsional, radial and axial loads. Coupling and exposed rotating components of the pump and motor shall be protected by an OSHA approved guard.

PART 3 – EXECUTION

3.1 INSTALLATION OF PUMPS:

A. Install pumps where indicated, in accordance with manufacturer’s published installation instruction, with recommended clearances provided for service and maintenance.

B. Install base-mounted pumps on minimum of 4” reinforced high concrete base with anchor bolts poured in place. Set and level pump, grout under pump base with non-shrink grout.

C. Provide piping; accessories; hangers, supports, and anchors; valves; meters and gauges; and equipment supports; as indicated for complete installation.

D. Pump and motor shall be realigned by the contractor, according to the standards of the Hydraulic Institute, after grouting of base and connection of piping.

E. Lubricate pumps before start-up. Start-up in accordance with manufacturer’s service representative.

F. Ensure that pump units are wired properly, with rotation in correct direction, and that pump and motor grounding have been provided.
Paco type KP, horizontal splitcase, double suction, centrifugal pumps are available with a wide selection of metallurgical and mechanical options to meet specific pumping requirements. Pump casings are horizontally split at the shaft centerline to simplify inspections and maintenance. Impellers are dynamically and hydraulically balanced. All Paco Type KP pumps are equipped with cartridge type bearing housings for ease of maintenance. Type KP splitcase pumps are available with packing and a variety of mechanical shaft seals.

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<td>Bronze, III932, C89835</td>
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<td>Seal Type</td>
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<td>O−Rings</td>
<td>Buna N</td>
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<td>NSF−61 Certification</td>
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Conditions of Service

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Motor Data

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<td>Three phase</td>
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<td>60</td>
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**KP – 6012–3/4 Configured Curve**

- **Project:** U A F Horiz. Split Case Sample  
  **Tag #** P–1  
  **P.O. #**

- **Location:** Fayetteville, AR  
  **Model:** 6012–3/4  
  **Cust Ref#**

- **Contractor:**  
  **Qty:** 1  
  **Agent/Rep:** Fluid Solutions, Inc.

- **Engineer:** T. M. E.  
  **Service:** Water  
  **Doc #**

---

### Design Data

- **Flow:** 1500 USgpm  
  **Fluid:** Water  
  **Suct. Press:** 0.00 psi.a

- **TDH:** 80.0 ft  
  **Temp:** 68.00 deg F  
  **Dis. Press:**

- **Shutoff Head:** 105 ft  
  **S.G.:** 0.998  
  **Diff. Press:**

- **NPSHr:** 7.71 ft  
  **Visc.:** 1.00 cP  
  **BHP:** 36.0 hp

- **Imp. Dia.:** 9.60 in  
  **Pump Eff.:** 83.92

- **No Of Stages:** 1  
  **BEP:** 1684 USgpm

---

### Motor Data

- **HP:** 40  
  **Voltage:** 208–230/460  
  **Eff.:**

- **Nominal RPM:** 1750  
  **Phase:** Three phase  
  **S.F.:** 1.15

- **Actual RPM:** 1780  
  **Hz:** 60  
  **Encl.:** ODP
PART 1 – GENERAL

1.1 SCOPE
A. Types of pumps specified in this section include:
   1. Frame Mounted Double Suction Pumps

1.2 RELATED WORK:
   A. Pumps furnished as part of factory-fabricated equipment are specified as part of the equipment assembly in other Division 15 sections.
   B. Motor starters, disconnects, and wiring of pump motors; Division 16
   C. Insulation of pump housings; Section 15250
   D. Sump pumps; Section 15450
   E. Pump system balancing; Section 15980
   F. Variable frequency drives; Section 15950

1.3 QUALITY ASSURANCE:
A. Manufacturers: Firms regularly engaged in manufacture of pumps of types and sizes required, whose products have been in satisfactory use in similar service for not less than five (5) years.
B. Provide electric motors and products which have been listed and labeled by Underwriters Laboratories and comply with NEMA standards.

1.4 SUBMITTALS:
A. Product Data: Submit manufacturers pump specifications, installation and start-up instructions, and current accurate pump characteristic performance curves with selection points clearly indicated.
B. Shop Drawings: Submit equipment connection and support details. Equipment connection details to indicate all piping connections with sizes and types of pipe, valves, fittings, specialties, and meter and gauges to be used. Support details to include fabricated, materials, and methods of support intended. Include detail of vibration isolation.
C. Operation and Maintenance Manual: Include maintenance data and spare parts lists for each type of pump.
PART 2 – PRODUCTS

2.1 GENERAL

A. Provide factory-tested pumps, thoroughly cleaned, and painted with one coat of machinery enamel prior to shipment. Type, size and capacity of each pump are listed in pump schedule.

2.2 DOUBLE SUCTION PUMPS

A. Furnish and install, as outlined on the equipment schedule and described in these specifications, a Paco model KP double suction, horizontal, split case, centrifugal pumps, or equal, designed to deliver the scheduled flow rate (in GPM), the specified total dynamic head (in feet), at the scheduled efficiency and scheduled speed (RPM).

To insure cavitation-free operation, each pump’s NPSH requirement must by low enough to permit stable, continuous operation at 120% or greater of best efficiency point.

B. Pumps shall have the casing divided on the horizontal centerline. The casing halves shall be accurately machined, bolted and doweled together. A non-asbestos type gasket material shall be furnished between the casing halves. The casing material shall be close-grained cast iron with a minimum tensile strength of 35,000 P.S.I. Removal of the uppercasing half and bearing housings shall permit removal of the complete rotating assembly without disturbing piping connections. Pumps shall be provided with removable bearing housings, which will permit inspection and/or replacement of the mechanical seals, shaft sleeves, and bearings without removing the rotating assembly or top casing half. Pumps with 4 inch or larger discharge flanges shall be of the double volute design.

C. Casings shall be designed for scheduled working pressure and shall be hydrostatically tested at 150% of the maximum working pressure under which the pump could operate at design speed. Suction and discharge flanges shall be drilled to ANSI Standards and be machined flat face. Pumps shall be fitted with lead-free bronze renewable case wear rings indexed with a dowel pin for fixed positioning.

D. The lead free bronze impeller shall be an enclosed Francis vane type, double suction design, hydraulically and dynamically balanced. The impeller is to be securely mounted on the pump shaft, and attached with a steel key. The impeller shall be locked in position by threaded shaft sleeves. The impeller shall be trimmed to meet the specific hydraulic requirements. Impeller trim must be equal to or less than 90% of maximum diameter, which will fit into the pump casing

E. The pump shaft shall be made of high tensile steel, precision ground to provide a true running rotating element.
F. The pump shaft shall be adequately supported by the pump bearings to limit the shaft deflection to 0.002 inches. Bearings shall be ball type, grease lubricated and locked to the shaft with positive locks of ample size to withstand any axial thrust loads. Each bearing housing shall be bolted to the upper and lower casing halves for a full 360-degree support registered fit to insure positive alignment. Bearing shall provide a minimum life of 10-years when calculated at 50% of Best-Efficiency-point for the scheduled pump.

G. The pump manufacturer shall recommend the proper mechanical seal based on the pressure, temperature and liquid outlined on the equipment schedule. Mechanical seals, at a minimum, shall have ceramic stationary seats, carbon rotating seats, and Buna elastomers.

H. Lead-free, bronze shaft sleeves shall be firmly attached to the pump shaft through threading and locking means. Shaft sleeve design shall prevent corrosion and wear to the shaft.

I. The pumps shall be mounted on a steel base with drip pan and directly connected through a heavy-duty flexible coupling to a horizontal motor as outlined in these specifications. The pump manufacturer shall provide an OSHA coupling guard, which shall be mounted between the pump and motor and attached firmly to the base.

J. The motor shall be sized to operate continuously without exceeding the horsepower rating (as outlined on the schedule) regardless of the flow and head throughout the operating range of the “System Curve.” Efficiencies shall be as defined in Section ________. Motor shall be of the horsepower and speed shown on the pump schedule. Pumps requiring larger horsepower motors shall not be acceptable. Motor shall be open drip proof type with 1.15-service factor 40 degree C ambient high efficiency type.

K. Manufacturer: Paco or approved equal.

PART 3 – EXECUTION

3.1 INSTALLATION OF PUMPS:

A. Install pumps where indicated, in accordance with manufacturer’s published installation instruction, with recommended clearances provided for service and maintenance.

B. Install base-mounted pumps on minimum of 4” reinforced high concrete base with anchor bolts poured in place. Set and level pump, grout under pump base with non-shrink grout.

C. Provide piping; accessories; hangers, supports, and anchors; valves; meters and gauges; and equipment supports; as indicated for complete installation.
D. Pump and motor shall be realigned by the contractor, according to the standards of the Hydraulic Institute, after grouting of base and connection of piping.

E. Lubricate pumps before start-up. Start-up in accordance with manufacturer’s service representative.

F. Ensure that pump units are wired properly, with rotation in correct direction, and that pump and motor grounding have been provided.
PACO type VLS Vertical In–Line Pumps are available in a wide selection of metallurgical and mechanical options to meet specific pumping requirements.

Suction and Discharge connections are the same size to simplify piping. The type VLS design incorporates a short shaft with minimum overhang reducing shaft deflection. Back pull out design allows rotating assembly to be removed without disturbing the volute or piping for ease of maintenance and service. PACO In–Line Pumps with discharge sizes 3 inch and larger feature a double volute design to reduce radial thrust and prolong bearing life.

PACO type VLS Vertical In–Line Pumps eliminate costly installation steps. They require 1/3 the space of a conventional pump installation and drastically reduce the cost of layout foundation and piping.

<table>
<thead>
<tr>
<th>Rotation Options</th>
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<th>Impeller</th>
<th>Silicon Bronze, ASTM–B584, C87600</th>
</tr>
</thead>
<tbody>
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<td>Impeller Cap Screw</td>
<td>S.S., AISI–303</td>
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<tr>
<td>Connections</td>
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<td>Impeller Washer</td>
<td>S.S., AISI–303</td>
</tr>
<tr>
<td>Wear Ring Type</td>
<td>Case Wear Ring</td>
<td>Impeller Key</td>
<td>Steel, AISI 1045</td>
</tr>
<tr>
<td>Pump Coatings</td>
<td>Standard Paint</td>
<td>Pump Shaft</td>
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<td>Steel, AISI 1045</td>
<td>Gaskets</td>
<td>Veg. Fiber</td>
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<td>Backplate/Seal Plate</td>
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<td>Casing Bolts</td>
<td>Steel, AISI 1045</td>
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<td>Motor Bracket</td>
<td>Cast Iron, ASTM–A48, CL 30</td>
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VLS – 60125 – Dim. Dwg

Project: U A F Vert. Split Coupled
Model: 60125
Location: Fayetteville, AR
Rotation: Clockwise
Contractor: Fluid Solutions, Inc.
Engineer: T. M. E.

P.O. #          By:            Date: 8/15/2006
Cust Ref#    Doc #

Rotation: Clockwise

Units Code FRAME S x D E DC DD DE X YY P AG Weight
inches XA 286HP 6 X 6 2.719 8.375 10.375 11.625 15 15 15.5 41 660

Conditions of Service
TDH: 80.0 ft Temp: 68.00 deg F RPM: 1750 Hz: 60 Voltage: 208–230/460 S.F.: 1.15

Motor Data

SUCTION

DISCHARGE

PLAN

SIDE VIEW

END VIEW
VLS – 60125 Configured Curve

By: James Dayer
Date: 8/15/2006

Project: U A F Vert. Split Coupled
Tag #: P-1
P.O. #: Cust Ref#

Location: Fayetteville, AR
Model: 60125

Contractor: Fluid Solutions, Inc.
Qty: 1
Agent/Rep: Fluid Solutions, Inc.

Engineer: T. M. E.
Service: Water
Doc #

---

**Design Data**

| Flow: 1000 USgpm | Fluid: Water | Suct. Press: 0.00 psi.a |
| TDH: 80.0 ft | Temp: 68.00 deg F | Dis. Press: |
| Shutoff Head: 103 ft | S.G.: 0.998 | Diff. Press: |
| NPSHr: 7.70 ft | Visc.: 1.00 cP | BHP: 25.2 hp |
| Imp. Dia.: 9.75 in | Pump Eff.: 80.02 |
| No Of Stages: 1 | BEP: 945 USgpm |

---

**Motor Data**

| HP: 30 | Voltage: 208–230/460 |
| Nominal RPM: 1750 | Phase: Three phase |
| Actual RPM: 1750 | S.F.: 1.15 |
| Hz: 60 | Encl.: ODP |
PART 1 – GENERAL

1.1 SCOPE
A. Types of pumps specified in this section include:
   1. Vertical In-Line Split Coupled Pumps.

1.2 RELATED WORK:
A. Pumps furnished as part of factory-fabricated equipment are specified as part of the equipment assembly in other Division 15 sections.
B. Motor starters, disconnects, and wiring of pump motors; Division 16
C. Insulation of pump housings; Section 15250
D. Sump pumps; Section 15450
E. Pump system balancing; Section 15980
F. Variable frequency drives; Section 15950

1.3 QUALITY ASSURANCE:
A. Manufacturers: Firms regularly engaged in manufacture of pumps of types and sizes required, whose products have been in satisfactory use in similar service for not less that five (5) years.
B. Provide electric motors and products which have been listed and labeled by Underwriters Laboratories and comply with NEMA standards.

1.4 SUBMITTALS:
A. Product Data: Submit manufacturers pump specifications, installation and start-up instructions, and current accurate pump characteristic performance curves with selection points clearly indicated.
B. Shop Drawings: Submit equipment connection and support details. Equipment connection details to indicate all piping connections with sizes and types of pipe, valves, fittings, specialties, and meter and gauges to be used. Support details to include fabricated, materials, and methods of support intended. Include detail of vibration isolation.
C. Operation and Maintenance Manual: Include maintenance data and spare parts lists for each type of pump.
PART 2 – PRODUCTS

2.1 GENERAL

A. Provide factory-tested pumps, thoroughly cleaned, and painted with one coat of machinery enamel prior to shipment. Type, size and capacity of each pump are listed in pump schedule.

2.2 Vertical In-Line Split Coupled Pumps

A. Furnish and install, as outlined on the equipment schedule and described in these specifications, a Paco model VLS vertical in-line, split coupled centrifugal pumps, or equal, designed to deliver the scheduled flow rate (in GPM), the specified total dynamic head (in feet), at the scheduled efficiency and scheduled speed (RPM). To insure cavitation-free operation, each pump’s NPSH requirement must be low enough to permit stable, continuous operation at 120% or greater of best efficiency point.

B. Pump casing shall be gray iron and shall be constructed with back pull-out capability. Models 3” and larger shall have balanced double volute design to reduce radial thrust and to prolong seal and bearing life. Pump casing shall incorporate a suction baffle to reduce pre-rotation and improve efficiency. Suction and Discharge connections shall be the same size, flanged (125, 250) PSI rating, 180 degrees opposite on centerline for pipeline mounting. Casing shall have bronze replaceable wear ring.

C. Impeller shall be cast bronze, enclosed, statistically, dynamically and hydraulically balanced, and shall be factory trimmed to match the delivery conditions indicated above.

D. The pump shaft shall be made of high tensile steel, precision ground to provide a true running rotating element.

E. The pump shaft shall be adequately supported by the pump bearings to limit the shaft deflection to 0.002 inches. Bearings shall be ball type, grease lubricated and locked to the shaft with positive locks of ample size to withstand any axial thrust loads. Each bearing housing shall be bolted to the upper and lower casing halves for a full 360-degree support registered fit to insure positive alignment. Bearing shall provide a minimum life of 10-years when calculated at 50% of Best-Efficiency-point for the scheduled pump.
F. The pump manufacturer shall recommend the proper mechanical seal based on the pressure, temperature and liquid outlined on the equipment schedule. Mechanical seals, at a minimum, shall have ceramic stationary seats, carbon rotating seats, and Buna elastomers.

G. Lead-free, bronze shaft sleeves shall be firmly attached to the pump shaft through threading and locking means. Shaft sleeve design shall prevent corrosion and wear to the shaft.

H. The pump manufacturer shall provide an OSHA coupling guard, which shall be mounted between the pump and motor and attached firmly to the base.

I. The motor shall be sized to operate continuously without exceeding the horsepower rating (as outlined on the schedule) regardless of the flow and head throughout the operating range of the “System Curve.” Efficiencies shall be as defined in Section __________. Motor shall be of the horsepower and speed shown on the pump schedule. Pumps requiring larger horsepower motors shall not be acceptable. Motor shall be open drip proof type with 1.15-service factor 40 degree C ambient high efficiency type.

J. Manufacturer: Paco or approved equal.

**PART 3 – EXECUTION**

3.1 INSTALLATION OF PUMPS:

A. Install pumps where indicated, in accordance with manufacturer’s published installation instruction, with recommended clearances provided for service and maintenance.

B. Install base-mounted pumps on minimum of 4” reinforced high concrete base with anchor bolts poured in place. Set and level pump, grout under pump base with non-shrink grout.

C. Provide piping; accessories; hangers, supports, and anchors; valves; meters and gauges; and equipment supports; as indicated for complete installation.

D. Pump and motor shall be realigned by the contractor, according to the standards of the Hydraulic Institute, after grouting of base and connection of piping.

E. Lubricate pumps before start-up. Start-up in accordance with manufacturer’s service representative.
F. Ensure that pump units are wired properly, with rotation in correct direction, and that pump and motor grounding have been provided.
STEAM PREHEAT COIL PIPING DETAIL

COIL DESIGNATION | A | B | C | D | E
---|---|---|---|---|---
HEATING COIL (HC-1) | 1-1/2" | 1-1/4" | 1-1/4" | 1-1/2" | ST-2

University of Arkansas at Fayetteville
Design Guide Details
STEAM PREHEAT COIL PIPING DETAIL

COIL DESIGNATION

<table>
<thead>
<tr>
<th>HEATING COIL (HC-1)</th>
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NOT TO SCALE
3
STEAM PREHEAT COIL PIPING DETAIL

NOT TO SCALE

University of Arkansas at Fayetteville
Design Guide Details
STEAM REHEAT COIL PIPING DETAIL

COIL DESIGNATION

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NOT TO SCALE
STEAM PREHEAT COIL PIPING DETAIL

NOT TO SCALE

COIL DESIGNATION  A   B   C
HEATING COIL (HC-1)  1-1/2"   1-1/4"   ST-2
STEAM PREHEAT COIL PIPING DETAIL

NOT TO SCALE

COIL DESIGNATION     A    B    C
HEATING COIL (HC-1)  1-1/2"  1-1/4"  ST-2

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Design Guide Details
STEAM REHEAT COIL PIPING DETAIL

SERVICING HEADER AND GATE VALVE

COIL DESIGNATION  | A  | B  | C
HEATING COIL (HC-1) | H-1/2" | 1-1/4" | 5T-2

STEAM RETURN

VEHICLE 1

6" LONG DI T RAP

PIPE SIZE SAME AS COIL CONNECTION

UNION

GATE VALVE

STRAINER WITH HOSE ADAPTER

CHECK VALVE

STEAM SUPPLY

*A* GATE VALVE

CONCENTRIC REDUCER

ECCENTRIC REDUCER

MODULATING CONTROL VALVE

VACUUM RELIEF JOHNSON VBB-1/2" (DO NOT USE CHECK VALVE)

AIR FLOW

COIL

F & T STEAM TRAP "C"

"B"

NOT TO SCALE
STEAM PREHEAT COIL PIPING DETAIL

NOT TO SCALE

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Design Guide Details

Det 9

Sheet 1 of 1
STEAM PREHEAT COIL PIPING DETAIL

COIL | A | B   | C   | D   | E   |
-----|---|-----|-----|-----|-----|
HEATING COIL (HC-1A) | 3" | 2-1/2" | 3" | 2-1/2" | ST-2A |
HEATING COIL (HC-1B) | 3" | 2-1/2" | 3" | 2-1/2" | ST-2B |

NOT TO SCALE
STEAM PREHEAT COIL PIPING DETAIL

NOT TO SCALE

COIL DESIGNATION  A  B  C  D  E
HEATING COIL (HC-1)  1-1/2"  1-1/4"  1-1/4"  1-1/2"  ST-2

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Design Guide Details
STEAM PREHEAT COIL PIPING DETAIL

NOT TO SCALE

COIL DESIGNATION   A   B   C
HEATING COIL (HC-1)  1-1/2"  1-1/4"  ST-2

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Design Guide Details
COIL DESIGNATION | A  | B  | C  |
----------------|----|----|----|
HEATING COIL (HC-1) | 1-1/2" | 1-1/4" | ST-2 |

STEAM PREHEAT COIL PIPING DETAIL

PIPE SIZE SAME AS COIL CONNECTION

6" LONG DIRT TRAP

AIR FLOW

10" MIN

STEAM RETURN

90°

CHECK VALVE

STRAINER WITH NOSE ADAPTER

GATE VALVE

FLEXIBLE CONNECTOR

UNION OR FLANGE

STRAINER

CONCENTRIC REDUCER

EGGNOX REDUCER

STEAM SUPPLY

GATE VALVE

STRAINER

MODULATING CONTROL VALVE

VACUUM RELIEF

DRAIN VALVE

DO NOT USE CHECK VALVE
STEAM REHEAT COIL PIPING DETAIL

COIL DESIGNATION  A    B    C
HEATING COIL (HC-1)  1-1/2"  1-1/4"  ST-2

STEAM RETURN
CHECK VALVE
UNION
GATE VALVE
STRAINER WITH NOSE ADAPTER
6" LONG DIRT TRAP

PIPE SIZE SAME AS COIL CONNECTION

AIR FLOW
STEAM PREHEAT COIL PIPING DETAIL

NOT TO SCALE
ST EAM PREHEAT COIL PIPING DETAIL

NOT TO SCALE
STEAM PREHEAT COIL PIPING DETAIL

NOT TO SCALE
PUMP WITH VFD

27 CHILLED WATER COIL PIPING DETAIL

NOT TO SCALE
PUMP WITH VFD

CHILLED WATER COIL PIPING DETAIL

NOT TO SCALE
CHILLED WATER COIL PIPING DETAIL

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NOT TO SCALE
CHILLED WATER COIL PIPING DETAIL

CHILLED WATER COIL PIPING DETAIL

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Design Guide Details
CHILLED WATER COIL PIPING DETAIL

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University of Arkansas at Fayetteville
Design Guide Details

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**CHILLED WATER COIL PIPING DETAIL**

*NOT TO SCALE*
CHILLED WATER COIL PIPING DETAIL

COIL DESIGNATION | A | B | C | D
---|---|---|---|---
COOLING COIL (CC-1A) | 3" | 2-1/2" | 3" | 2-1/2"
COOLING COIL (CC-1B) | 3" | 2-1/2" | 3" | 2-1/2"
COOLING COIL (CC-2A) | 3" | 2-1/2" | 3" | 2-1/2"
COOLING COIL (CC-2B) | 3" | 2-1/2" | 3" | 2-1/2"

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Design Guide Details
CHILLED WATER COIL PIPING DETAIL

NOT TO SCALE
STEAM HUMIDIFIER PIPING DETAIL

NOTE:
VERIFY PIPE SIZES AND ARRANGEMENT WITH HUMIDIFIER MANUFACTURERS' RECOMMENDATIONS.
Condensate Drain Piping Detail

**BLOW-THRU COIL**
(POSITIVE PRESSURE)
- \( A' = 1' \) (MINIMUM)
- \( B' = 1' \) + STATIC PRESSURE
- \( C' = 2' \)
- \( D' = \text{PIPE DIAMETER} \)
- \( E' = A' + B' + (1.5' \times D') \)
- \( F' = 3' \)

**DRAIN PAN**

**FILE SINK**

**CLEAN OUT**

**SILOHON BREAK**

**TOP OF DRAIN PAN**

**BOTTOM OF DRAIN**

**DRAW-THRU COIL**
(NEGATIVE PRESSURE)
- \( A = 1' \) + STATIC PRESSURE
- \( B' = 1/2' \times A' \)
- \( C' = 2' \)
- \( D' = \text{PIPE DIAMETER} \)
- \( E' = A' + B' + (1.5' \times D') \)
- \( F' = 3' \)

**NOT TO SCALE**
CONDENSATE DRAIN PIPING DETAIL

NOT TO SCALE
NOTE: USE 2-WAY CONTROL VALVES UNLESS SPECIFICALLY INDICATED TO USE A 3-WAY CONTROL AT CERTAIN AIR TERMINALS.
Typical Hot Water Coil Piping Detail

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Design Guide Details
FOR ALL NON-SBS JOBS

TYPICAL AIR TERMINAL DETAIL

48

NOT TO SCALE
FOR ALL NON-SBS JOBS

FLEXIBLE AIR DUCT
MAXIMUM LENGTH 3'-0"

HIGH VELOCITY SUPPLY AIR DUCTWORK REFER TO FLOOR PLANS AND SCHEDULES FOR SIZES

TRANSITION AS REQUIRED

METAL DUCT CONNECTION TO AIR TERMINAL

AVERAGING VELOCITY SENSOR

AIR TERMINAL IDENTIFICATION TAG AND BALANCING INFORMATION

AIR TERMINAL CONTROLLER SPECIFIED IN SECTION 5900, MOUNT CONTROLLER IN AN ACCESSIBLE LOCATION.

ELECTRIC HEATING COIL

LOW VELOCITY SUPPLY AIR DUCTWORK REFER TO FLOOR PLANS AND SCHEDULES FOR SIZES

TRANSITION AS REQUIRED

HEATING COIL CONTROL PANEL PROVIDE ADEQUATE CLEARANCE FOR SERVICE AND MAINTENANCE

TYPICAL AIR TERMINAL DETAIL

49 NOT TO SCALE

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Design Guide Details
50 TYPICAL EXHAUST TERMINAL DETAIL

DAMPER ACTUATOR SPECIFIED IN SECTION 15400
REFER TO CONTROL SCHEMATICS FOR TYPE

PROVIDE REQUIRED LENGTH OF STRAIGHT
DUCT UPSTREAM OF TERMINAL, COORDINATE
WITH TERMINAL MANUFACTURER.

EXHAUST AIR DUCTWORK, REFER
TO FLOOR PLANS FOR SIZES

TRANSITION AS REQUIRED

ORIFICE TYPE AIR FLOW MEASURING DEVICE

EXHAUST TERMINAL

TRANSITION AS REQUIRED

EXHAUST AIR DUCTWORK, REFER
TO FLOOR PLANS FOR SIZES

TO ENERGY RECOVERY UNITS
FOR SBS JOBS ONLY

TYPICAL AIR TERMINAL DETAIL

NOT TO SCALE
NOTE:
FLEXIBLE DUCT CONNECTIONS SHALL BE INSTALLED TO ADC STANDARDS AND SEALED TO UL STANDARDS PER AMC 603 AND 604.21. AS A MINIMUM, THE CONTRACTOR SHALL SECURE THE FLEXIBLE DUCT TO GRILLE AND METAL DUCT WITH DRAMBANDS, AND WRAP 3" WIDE ALUMINUM TAPE EQUALLY TO HARDCAST "FOIL GRIP" AROUND DRAMBAND AND EXPOSED END OF FLEXIBLE DUCT INSULATION.

DIFFUSER CONNECTION TO RECTANGULAR DUCT
NOT TO SCALE
FOR SBS JOBS ONLY

NOTE:
FLEXIBLE DUCT CONNECTIONS SHALL BE INSTALLED TO ADC STANDARDS AND SEALED TO UL STANDARDS PER AMC 603 AND 604.21. AS A MINIMUM, THE CONTRACTOR SHALL SECURE THE FLEXIBLE DUCT TO ENDS OF METAL DUCT WITH DRAMBANDS, AND WRAP 3" WIDE ALUMINUM TAPE EQUAL TO HARDCAST "FOIL GRIP" AROUND DRAMBAND AND EXPOSED END OF FLEXIBLE DUCT INSULATION.

DIFFUSER CONNECTION TO ROUND DUCT

NOT TO SCALE
NOTE:
FLEXIBLE DUCT CONNECTIONS SHALL BE INSTALLED TO ADC STANDARDS AND
SEALED TO UL STANDARDS PER AMC 603 AND 604.21. AS A MINIMUM, THE
CONTRACTOR SHALL SECURE THE FLEXIBLE DUCT TO GRILLE AND METAL DUCT
WITH DRAMBANDS, AND WRAP 3" WIDE ALUMINUM TAPE EQUAL TO HARDCAST
"FOIL GRIP" AROUND DRAMBAND AND EXPOSED END OF FLEXIBLE DUCT INSULATION.

55 DIFFUSER CONNECTION TO ROUND DUCT
NOT TO SCALE
FOR ALL NON-SBS JOBS

University of Arkansas at Fayetteville
Design Guide Details
NOTE:
FLEXIBLE DUCT CONNECTIONS SHALL BE INSTALLED TO ADC STANDARDS AND SEALED TO UL STANDARDS PER AMC 603 AND 604.21. AS A MINIMUM, THE CONTRACTOR SHALL SECURE THE FLEXIBLE DUCT TO GRILLE AND METAL DUCT WITH DRAWBANDS, AND WRAP 3" WIDE ALUMINUM TAPE EQUAL TO HARDCAST "FOIL GRIP" AROUND DRAWBAND AND EXPOSED END OF FLEXIBLE DUCT INSULATION.
NOTE:
FLEXIBLE DUCT CONNECTIONS SHALL BE INSTALLED TO ADC STANDARDS AND
SEALED TO UL STANDARDS PER AMC 603 AND 604.2.1 AS A MINIMUM, THE
CONTRACTOR SHALL SECURE THE FLEXIBLE DUCT TO GRILLE AND METAL DUCT
WITH DRAMBANDS, AND WRAP 3" WIDE ALUMINUM TAPE EQUAL TO HARDCAST
"FOIL GRIP" AROUND DRAMBAND AND EXPOSED END OF DUCT INSULATION.

DIFFUSER CONNECTION W/ FIRE DAMPER

(Not to Scale)
NOTE:
FLEXIBLE DUCT CONNECTIONS SHALL BE INSTALLED TO ADC STANDARDS AND SEALED TO UL STANDARDS PER AMC 603 AND 604.2J. AS A MINIMUM, THE CONTRACTOR SHALL SECURE THE FLEXIBLE DUCT TO ENDS OF METAL DUCT WITH DRAWBANDS, AND WRAP 3" WIDE ALUMINUM TAPE EQUAL TO HARDCAST "FOIL GRIP" AROUND DRAWBAND AND EXPOSED END OF FLEXIBLE DUCT INSULATION.

DIFFUSER CONNECTION W/ FIRE DAMPER

NOT TO SCALE
**RETURN AIR GRILLE WITH ELL DETAIL**

**NOT TO SCALE**

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**DESIGNATION**

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- **NECK "C" BY "D"**
- **CEILING TILE**
- **CEILING GRID**
- **GRILLE "A" BY "B"**
- **DUCT "E" WIDTH BY "F" HEIGHT**
- **PERFORATED FACE, LAY IN RETURN AIR GRILLE**
RETURN AIR GRILLE WITH INSULATED ELL DETAIL

NOT TO SCALE

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</table>
NOTES:

1. COMPLY W SMACNA "FIRE, SMOKE AND RADIATION DAMPER INSTALLATION GUIDE FOR HVAC SYSTEMS" AND NFPA 90A "INSTALLATION OF AIR CONDITIONING AND VENTILATING SYSTEMS".
2. GALVANIZED SLEEVE GAGE SHALL NOT BE LESS THAN CONNECTING DUCT FOR BREAKAWAY CONNECTED DUCT. BREAKAWAY DUCT CONNECTION MAY BE OMITTED IF SLEEVE IS 16 GA., MINIMUM.
3. GALVANIZED STEEL PERIMETER ANGLE NOT LESS THAN 1-1/2X1-1/2X1/4 GAGE WITH 1" MINIMUM OVERLAP ON ALL SIDES.
4. BREAKAWAY DUCT CONNECTION REFER TO SMACNA FIGURE 2-2 "UL ACCEPTED DUCT-SLEEVE CONNECTIONS" OF FIRE, SMOKE AND RADIATION DAMPER INSTALLATION GUIDE, UL TESTED DUCT SEALANT MAY BE USED.
   BREAKAWAY DUCT CONNECTION MAY BE OMITTED IF SLEEVE IS 16 GA., MINIMUM.
5. PROVIDE 1/4" TO 1/2" CLEARANCE ON HEIGHT AND WIDTH, FILL OPEN SPACE WITH FIRE STOPPING MATERIAL.
6. FIRE DAMPER SLEEVE TO EXTEND 6" MINIMUM ON EACH SIDE.
NOTES:

1. COMPLY WITH SMACNA "FIRE, SMOKE AND RADIATION DAMPER INSTALLATION GUIDE FOR HVAC "SYSTEMS" AND NFPA 90A "INSTALLATION OF AIR CONDITIONING AND VENTILATING SYSTEMS".
2. GALVANIZED SLEEVE GAUGE SHALL NOT BE LESS THAN CONNECTING DUCT FOR BREAKAWAY CONNECTED DUCT. BREAKAWAY DUCT CONNECTION MAY BE OMITTED IF SLEEVE IS 16 GA, MINIMUM.
3. GALVANIZED STEEL PERIMETER ANGLE NOT LESS THAN 1-1/2x1-1/2x14 GAGE WITH 1" MINIMUM OVERLAP ON ALL SIDES.
4. BREAKAWAY DUCT CONNECTION. REFER TO SMACNA FIGURE 2-2 "UL ACCEPTED DUCT-SLEEVE CONNECTIONS" OF FIRE, SMOKE AND RADIATION DAMPER INSTALLATION GUIDE. UL TESTED DUCT SEALANT MAY BE USED. BREAKAWAY DUCT CONNECTION MAY BE OMITTED IF SLEEVE IS 16 GA, MINIMUM.
5. PROVIDE 1/4" TO 1/2" CLEARANCE ON HEIGHT AND WIDTH. FILL OPEN SPACE WITH FIRE STOPPING MATERIAL.
6. FIRE DAMPER SLEEVE TO EXTEND 6" MINIMUM ON EACH SIDE. REFER TO CONTROL SCHEMATIC FOR APPLICABLE OPERATOR OR ACTUATOR.
NOTES:
1. COMPLY W/ SMACNA "FIRE, SMOKE AND RADIATION DAMPER INSTALLATION GUIDE FOR HVAC "SYSTEMS" AND NFPA 90A "INSTALLATION OF AIR CONDITIONING AND VENTILATING SYSTEMS".
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5. PROVIDE 1/4" TO 1/2" CLEARANCE ON HEIGHT AND WIDTH. FILL OPEN SPACE WITH FIRE STOPPING MATERIAL.
6. FIRE DAMPER SLEEVE TO EXTEND 6" MINIMUM ON EACH SIDE.
   REFER TO CONTROL SCHEMATIC FOR APPLICABLE OPERATOR OR ACTUATOR

64 COMBINATION FIRE AND SMOKE DAMPER DETAIL
NOT TO SCALE
NOTES:
1. COMPLY W/ SMACNA "FIRE, SMOKE AND RADIATION DAMPER INSTALLATION GUIDE FOR HVAC "SYSTEMS" AND NFPA 90A "INSTALLATION OF AIR CONDITIONING AND VENTILATING SYSTEMS".
2. GALVANIZED SLEEVE GAGE SHALL NOT BE LESS THAN CONNECTING DUCT FOR BREAKAWAY CONNECTED DUCT. BREAKAWAY DUCT CONNECTION MAY BE OMITTED IF SLEEVE IS 16 GA, MINIMUM.
3. GALVANIZED STEEL PERIMETER ANGLE NOT LESS THAN 1-1/2"X1-1/2"X14 GAGE WITH 1" MINIMUM OVERLAP ON ALL SIDES.
4. BREAKAWAY DUCT CONNECTION REFER TO SMACNA FIGURE 2-2 "UL ACCEPTED DUCT-SLEEVE CONNECTIONS" OF FIRE, SMOKE AND RADIATION DAMPER INSTALLATION GUIDE. UL TESTED DUCT SEALANT MAY BE USED. BREAKAWAY DUCT CONNECTION MAY BE OMITTED IF SLEEVE IS 16 GA, MINIMUM.
5. PROVIDE 1/4" TO 1/2" CLEARANCE ON HEIGHT AND WIDTH. FILL OPEN SPACE WITH FIRE STOPPING MATERIAL.
6. FIRE DAMPER SLEEVE TO EXTEND 6" MINIMUM ON EACH SIDE.

VERTICAL FIRE DAMPER DETAIL

NOT TO SCALE
NOTES:
1. Comply w/ SMACNA "FIRE, SMOKE AND RADIATION DAMPER INSTALLATION GUIDE FOR HVAC SYSTEMS" and NFPA 40A "INSTALLATION OF AIR CONDITIONING AND VENTILATING SYSTEMS".
2. Galvanized sleeve gage shall not be less than connecting duct for breakaway connected duct. Breakaway duct connection may be omitted if sleeve is 16 ga, minimum.
3. Galvanized steel perimeter angle not less than 1-1/2x1-1/2x14 gage with 1" minimum overlap on all sides.
4. Breakaway duct connection. Refer to SMACNA Figure 2-2 "UL accepted duct-sleeve connections" of fire, smoke and radiation damper installation guide. UL tested duct sealant may be used. Breakaway duct connection may be omitted if sleeve is 16 ga, minimum.
5. Provide 1/4" to 1/2" clearance on height and width. Fill open space with fire stopping material.
6. Fire damper sleeve to extend 6" minimum on each side. Refer to control schematic for applicable operator or actuator.

VERTICAL FIRE AND SMOKE DAMPER DETAIL

NOT TO SCALE
NOTES:
1. COMPARE W/ SMACNA "FIRE, SMOKE AND RADIATION DAMPER INSTALLATION GUIDE FOR HVAC "SYSTEMS" AND NFPA 90A "INSTALLATION OF AIR CONDITIONING AND VENTILATING SYSTEMS".
2. GALVANIZED SLEEVE GAGE SHALL NOT BE LESS THAN CONNECTING DUCT FOR BREAKAWAY CONNECTED DUCT. BREAKAWAY DUCT CONNECTION MAY BE OMITTED IF SLEEVE IS 16 GA. MINIMUM.
3. GALVANIZED STEEL PERIMETER ANGLE NOT LESS THAN 1-1/2X1-1/2X14 GAGE WITH 1" MINIMUM OVERLAP ON ALL SIDES.
4. BREAKAWAY DUCT CONNECTION, REFER TO SMACNA FIGURE 2-2 "UL ACCEPTED DUCT-SLEEVE CONNECTIONS" OF FIRE, SMOKE AND RADIATION DAMPER INSTALLATION GUIDE. UL TESTED DUCT SEALANT MAY BE USED.
5. PROVIDE 1/4" TO 1/2" CLEARANCE ON HEIGHT AND WIDTH, FILL OPEN SPACE WITH FIRE STOPPING MATERIAL.
6. FIRE DAMPER SLEEVE TO EXTEND 6" MINIMUM ON EACH SIDE.

HORIZONTAL FIRE DAMPER DETAIL

NOT TO SCALE
NOTES:
1. COMPLY W/ SMACNA "FIRE, SMOKE AND RADIATION DAMPER INSTALLATION GUIDE FOR HVAC "SYSTEMS" AND NFPA 90A "INSTALLATION OF AIR CONDITIONING AND VENTILATING SYSTEMS".
2. GALVANIZED SLEEVE GAGE SHALL NOT BE LESS THAN CONNECTING DUCT FOR BREAKAWAY CONNECTED DUCT. BREAKAWAY DUCT CONNECTION MAY BE OMITTED IF SLEEVE IS 16 GA. MINIMUM.
3. GALVANIZED STEEL PERIMETER ANGLE NOT LESS THAN 1-1/2X1-1/2X14 GAGE WITH 1" MINIMUM OVERLAP ON ALL SIDES.
4. BREAKAWAY DUCT CONNECTION. REFER TO SMACNA FIGURE 2-2 "UL ACCEPTED DUCT-SLEEVE CONNECTIONS" OF FIRE, SMOKE AND RADIATION DAMPER INSTALLATION GUIDE. UL TESTED DUCT SEALANT MAY BE USED. BREAKAWAY DUCT CONNECTION MAY BE OMITTED IF SLEEVE IS 16 GA. MINIMUM.
5. PROVIDE 1/4" TO 1/2" CLEARANCE ON HEIGHT AND WIDTH. FILL OPEN SPACE WITH FIRE STOPPING MATERIAL.
6. FIRE DAMPER SLEEVE TO EXTEND 6" MINIMUM ON EACH SIDE.
7. REFER TO CONTROL SCHEMATIC FOR APPLICABLE OPERATOR OR ACTUATOR.
NOTES:
1. Comply with SMACNA "FIRE, SMOKE AND RADIATION DAMPER INSTALLATION GUIDE FOR HVAC SYSTEMS" AND NFPA 90A "INSTALLATION OF AIR CONDITIONING AND VENTILATING SYSTEMS".
2. Galvanized sleeve gage shall not be less than connecting duct for breakaway connected duct. Breakaway duct connection may be omitted if sleeve is 16 ga., minimum.
3. Galvanized steel perimeter angle not less than 1/2x1/2x4 gage with 1" minimum overlap on all sides.
4. Breakaway duct connection. Refer to SMACNA Figure 2-2 "UL accepted duct-sleeve connections" of fire, smoke and radiation damper installation guide. UL tested duct sealant may be used. Breakaway duct connection may be omitted if sleeve is 16 ga., minimum.
5. Provide 1/4" to 1/2" clearance on height and width. Fill open space with fire stopping material.
6. Fire damper sleeve to extend 6" minimum on each side.
7. Refer to control schematic for applicable operator or actuator.
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3. GALVANIZED STEEL PERIMETER ANGLE NOT LESS THAN 1-1/2X1-1/2X1/4" GAGE WITH 1" MINIMUM OVERLAP ON ALL SIDES.
4. BREAKAWAY DUCT CONNECTION. REFER TO SMACNA FIGURE 2-2 "UL ACCEPTED DUCT-SLEEVE CONNECTIONS" OF FIRE, SMOKE AND RADIATION DAMPER INSTALLATION GUIDE. UL TESTED DUCT SEALANT MAY BE USED. BREAKAWAY DUCT CONNECTION MAY BE OMITTED IF SLEEVE IS 16 GA, MINIMUM.
5. PROVIDE 1/4" TO 1/2" CLEARANCE ON HEIGHT AND WIDTH. FILL OPEN SPACE WITH FIRE STOPPING MATERIAL.
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4. BREAKAWAY DUCT CONNECTION. REFER TO SMACNA FIGURE 2-2 "UL ACCEPTED DUCT-SLEEVE CONNECTIONS" OF FIRE, SMOKE AND RADIATION DAMPER INSTALLATION GUIDE. UL TESTED DUCT SEALANT MAY BE USED. BREAKAWAY DUCT CONNECTION MAY BE OMITTED IF SLEEVE IS 16 GA. MINIMUM.
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6. FIRE DAMPER SLEEVE TO EXTEND 6" MINIMUM ON EACH SIDE.
7. REFER TO CONTROL SCHEMATIC FOR APPLICABLE OPERATOR OR ACTUATOR.

HORIZONTAL FIRE AND SMOKE DAMPER DETAIL

NOT TO SCALE
1 or 2 hour gypsum wall assembly (2300 or 1400 series wall and partition design in "UL Fire Resistance Directory")

SEALANT GROWN 1/4" (MINIMUM)
SEALANT DEPTH 1/4" MINIMUM

SECTION A-A

REFERENCE SEALANT | MAXIMUM PIPE DIAMETER (IN) | ANNULAR SPACE (IN) | FIRE RATING (HR)
--- | --- | --- | ---
3M CP 256KH | 1" | 0" to 3/8" | 2
3M CP 256KH | 4" | 0" to 1/2" | 2
3M CP 256KH+ | 12" | 3/8" to 3/8" | 2

12" or smaller schedule 10 (MN) steel pipe
12" or smaller service height cast iron
12" or smaller class 50 (MN) ductile iron
6" or smaller type L copper pipe
4" or smaller EMT

NOTE: THIS DETAIL REPRESENTS ONE MANUFACTURER'S RECOMMENDATION FOR A WALL TYPE. THE CONTRACTOR SHALL CONSULT THE FIRE STOPPING MATERIALS MANUFACTURER FOR SPECIFIC INFORMATION AND SPECIFIC INSTALLATION INSTRUCTIONS FOR THE WALLS AND PARTITIONS APPLICABLE TO THIS PROJECT.

METAL PIPE PENETRATION THRU RATED GYPSUM WALL

NOT TO SCALE
1 OR 2 HOUR GYPSUM WALL ASSEMBLY (1300 OR 1400 SERIES WALL AND PARTITION DESIGN IN "UL FIRE RESISTANCE DIRECTORY")

1/4" CROWN (MINIMUM) ON SEALANT

SECTION A-A

INSULATION, REFER TO TABLE FOR INSULATION TYPE REQUIRED BY WALL RATING AND INSULATION THICKNESS

24" OR SMALLER SCHEDULE 10 (MIN) STEEL PIPE
6" OR SMALLER TYPE "L" COPPER PIPE
4" OR SMALLER EMT

SEALANT DEPTH 1/4" MINIMUM

INSULATION JACKET, REFER TO TABLE FOR TYPE

NOTE: THIS DETAIL REPRESENTS ONE MANUFACTURER'S-RECOMMENDATION FOR A WALL TYPE. THE CONTRACTOR SHALL CONSULT THE FIRE STOPPING MATERIALS MANUFACTURER FOR SPECIFIC INFORMATION AND SPECIFIC INSTALLATION INSTRUCTIONS FOR THE WALLS AND PARTITIONS APPLICABLE TO THIS PROJECT.

<table>
<thead>
<tr>
<th>REFERENCE SEALANT</th>
<th>INSULATION TYPE</th>
<th>MAX. INSULATION THICKNESS (IN)</th>
<th>FIRE RATING (HR)</th>
<th>INSULATION SHEATHING MATERIAL</th>
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<tr>
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<td>3M FB-2000</td>
<td>MINERAL WOOL</td>
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<td>ASJ</td>
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73 INSULATED METAL PIPE PENETRATION THRU RATED GYPSUM WALL

NOT TO SCALE
1 or 2 hour gypsum wall assembly (U300 or U400 series wall and partition design in "UL fire resistance directory")

SECTION A-A

SEALANT GROWN 1/4" (MINIMUM)
SEALANT DEPTH 1-1/4" MINIMUM

12" or smaller schedule 10 (min) steel pipe
12" or smaller service height cast iron
12" or smaller class 50 (min) ductile iron
6" or smaller type 1" copper pipe

INSTALL ESCUTCHEON RING ON EACH SIDE OF FLOOR OR WALL

NOTE: This detail represents one manufacturer's recommendation for a wall type. The contractor shall consult the fire stopping materials manufacturer for specific information and specific installation instructions for the walls and partitions applicable to this project.

METAL PIPE PENETRATION THRU RATED GYPSUM WALL

FOR SBS JOBS ONLY

University of Arkansas at Fayetteville
Design Guide Details
NOTE: THIS DETAIL REPRESENTS ONE MANUFACTURER'S RECOMMENDATION FOR A WALL TYPE. THE CONTRACTOR SHALL CONSULT THE FIRE STOPPING MATERIALS MANUFACTURER FOR SPECIFIC INFORMATION AND SPECIFIC INSTALLATION INSTRUCTIONS FOR THE WALLS AND PARTITIONS APPLICABLE TO THIS PROJECT.

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<th>REFERENCE SEALANT</th>
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<th>MAX. INSULATION THICKNESS (IN)</th>
<th>FIRE RATING (HRS)</th>
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<tr>
<td>3M FB-2000</td>
<td>FIBERGLASS</td>
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<td>3M FB-2000</td>
<td>MINERAL WOOL</td>
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<td>ASJ</td>
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75 INSULATED METAL PIPE PENETRATION thru RATED GYPSUM WALL

NOT TO SCALE
NOTE: THIS DETAIL REPRESENTS ONE MANUFACTURER'S RECOMMENDATION FOR A WALL TYPE. THE CONTRACTOR SHALL CONSULT THE FIRE STOPPING MATERIALS MANUFACTURER FOR SPECIFIC INFORMATION AND SPECIFIC INSTALLATION INSTRUCTIONS FOR THE WALLS AND PARTITIONS.

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<tr>
<th>REFERENCE SEALANT</th>
<th>MAXIMUM PIPE DIAMETER (IN)</th>
<th>MAX. ANNULAR SPACE (IN)</th>
<th>FIRE RATING (HRS)</th>
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<td>3M CP 25N/5</td>
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<td>3M CP 25N/5</td>
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<td>2-1/2&quot;</td>
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</tbody>
</table>

INSULATED METAL PIPE PENETRATION THRU RATED CONCRETE FLR OR WALL

FOR ALL NON-SBS JOBS
1" DEPTH SEALANT FOR 1" THICKNESS PIPE INSULATION, 2" DEPTH SEALANT FOR 2" THICKNESS PIPE INSULATION, REFER TO TABLE FOR WIDTH OF ANNULAR SPACE

1" OR 2" THICKNESS FIBERGLASS PIPE INSULATION WITH ALL SERVICE JACKET

MINIMUM 2-1/2" THICK REINFORCED (100 TO 150 PCF) CONCRETE OR UL CLASSIFIED CONCRETE BLOCKS

MINIMUM 1" THICKNESS MINERAL WOOL PACKING

NOTE: THIS DETAIL REPRESENTS ONE MANUFACTURER’S RECOMMENDATION FOR A WALL TYPE. THE CONTRACTOR SHALL CONSULT THE FIRE STOPPING MATERIALS MANUFACTURER FOR SPECIFIC INFORMATION AND SPECIFIC INSTALLATION INSTRUCTIONS FOR THE WALLS AND PARTITIONS

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<th>ANNULAR SPACE (IN)</th>
<th>FIRE RATING (HRS)</th>
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<tbody>
<tr>
<td>3M CP 25MB+</td>
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<td>3M CP 25MB+</td>
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<tr>
<td>3M CP 25MB+</td>
<td>2-1/2&quot;</td>
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<td>1/2&quot; TO 1-1/2&quot;</td>
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<tr>
<td>3M CP 25MB+</td>
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<td>1/2&quot; TO 2-3/8&quot;</td>
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INSULATED METAL PIPE PENETRATION THRU RATED CONCRETE FLOOR OR WALL

NOT TO SCALE

FOR ALL NON-SBS JOBS
METAL PIPE PENETRATION thru RATED CONCRETE FLOOR OR WALL

NOT TO SCALE

FOR SBS JOBS ONLY

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<tr>
<th>REFERENCE SEALANT</th>
<th>MAXIMUM PIPE DIAMETER (IN)</th>
<th>MAX. ANNULAR SPACE (IN)</th>
<th>FIRE RATING (HR)</th>
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<th>ANNULAR SPACE (IN.)</th>
<th>FIRE RATING (HRS.)</th>
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<td>3M CP 25WB+</td>
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<td>3M CP 25WB+</td>
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<td>3M CP 25WB+</td>
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</tbody>
</table>

**INSULATED METAL PIPE PENETRATION thru RATED CONCRETE FLOOR OR WALL**

**NOT TO SCALE**

FOR SBS JOBS ONLY
NOTE: THIS DETAIL REPRESENTS ONE MANUFACTURER'S RECOMMENDATION FOR A WALL TYPE. THE CONTRACTOR SHALL CONSULT THE FIRE STOPPING MATERIALS MANUFACTURER FOR SPECIFIC INFORMATION AND SPECIFIC INSTALLATION INSTRUCTIONS FOR THE WALLS AND PARTITIONS.

<table>
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<th>REFERENCE SEALANT</th>
<th>REFERENCE WRAP STRIP</th>
<th>MINIMUM FLOOR OR WALL THICKNESS (IN)</th>
<th>MAXIMUM PIPE DIAMETER (IN)</th>
<th>MAX INSULATION THICKNESS (IN)</th>
<th>ANNULAR SPACE (IN)</th>
<th>MINIMUM NUMBER OF WRAP STRIP LAYERS</th>
<th>FIRE RATING (HRS)</th>
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INSULATED METAL PIPE PENETRATION
thru RATED CONCRETE FLOOR OR WALL
NOT TO SCALE

FOR ALL NON-SBS JOBS
INSULATED METAL PIPE PENETRATION
thru RATED CONCRETE FLOOR OR WALL

NOTE: THIS DETAIL REPRESENTS ONE MANUFACTURER’S RECOMMENDATION FOR A WALL TYPE. THE CONTRACTOR SHALL CONSULT THE FIRE STOPPING MATERIALS MANUFACTURER FOR SPECIFIC INFORMATION AND SPECIFIC INSTALLATION INSTRUCTIONS FOR THE WALLS AND PARTITIONS.

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<td>3M FS-195+</td>
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<td>3M FS-195+</td>
<td>4-1/2&quot;</td>
<td>20&quot;</td>
<td>1&quot;</td>
<td>1/2&quot; TO 1&quot;</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3M CP 25WB+</td>
<td>3M FS-195+</td>
<td>4-1/2&quot;</td>
<td>30&quot;</td>
<td>2&quot;</td>
<td>3/4&quot; TO 1-1/4&quot;</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3M CP 25WB+</td>
<td>3M FS-195+</td>
<td>4-1/2&quot;</td>
<td>20&quot;</td>
<td>3&quot;</td>
<td>1&quot; TO 1-1/2&quot;</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

FOR SBS JOBS ONLY

University of Arkansas at Fayetteville
Design Guide Details
INSULATED METAL PIPE PENETRATION THRU RATED CONCRETE FLOOR OR WALL

FOR SBS JOBS ONLY

INSTRUCTIONS FOR INSTALLATION

STEP 1 - PREPARATION
All surfaces should be clean, sound and dry prior to application of fire-stopping materials, do not remove pipe insulation.

STEP 2 - FIRE-STOP SEALANT
Seal the annular space around the pipe with a 1/4" layer of fire-stop sealant.

STEP 3 - INTUMESCENT WRAP
Measure and cut enough intumescent wrap to completely circle the pipe once. Wrap it snuggly around the pipe, foil side out, buttting the ends, and tape in place using wrap tape. Install a second layer of wrap in the same manner, then slide both layers up the pipe, butting them against the surface of the wall or ceiling. Wall penetrations require a symmetrical system on both sides.

STEP 4 - RETAINING COLLAR
Measure and cut enough retaining collar to encircle the intumescent wrap and overlap the ends approximately 1/2. Bend the anchor tabs outward 45 degrees. Then place the collar snugly around the wrap and tighten it with a single collar clamp at mid height. Fasten the anchor tabs to the substrate using 1/4" dia. expansion bolts. To complete the installation, bend the support tabs inward toward the pipe.

NOTE: THIS DETAIL REPRESENTS ONE MANUFACTURER'S RECOMMENDATIONS FOR GENERAL USE. APPLICATIONS MAY VARY, THEREFORE THE CONTRACTOR SHALL CONSULT THE FIRE-STOPPING MATERIAL'S MANUFACTURER FOR SPECIFIC INFORMATION AND INSTALLATION INSTRUCTIONS.
METAL PIPE PENETRATION thru RATED CONCRETE FLOOR OR WALL

FOR SBS JOBS ONLY

INSTRUCTIONS FOR INSTALLATION

STEP 1 - PREPARATION
ALL SURFACES SHOULD BE CLEAN, SOUND AND DRY PRIOR TO APPLICATION OF FIRESTOPPING MATERIALS.

STEP 2 - BACKING MATERIAL
FILL AROUND THE PIPE, LEAVING APPROPRIATE SPACE FOR THE SEALANT, AND ALLOW THE FOAM TO CURE.

STEP 3 - FIRESTOP SEALANT
APPLY REQUIRED DEPTH OF FIRESTOP SEALANT AND TOOL WITH PUTTY KNIFE UNTIL FLUSH WITH THE SURFACE. WALL PENETRATIONS REQUIRE SEALANT ON BOTH SIDES, LEAVE COMPLETED SEAL UNDISTURBED FOR 48 HOURS.

NOTE: 1. IN WALLS, INSTALL FIRESTOP SYSTEM SYMMETRICALLY ON BOTH SIDES.
2. IF WALLS ARE MASONRY, MINIMUM THICKNESS = 8".

<table>
<thead>
<tr>
<th>MINIMUM CONCRETE THICKNESS</th>
<th>MAX. SIZE PIPE/CONDUIT</th>
<th>STEEL SLEEVE</th>
<th>ANNULAR SPACE</th>
<th>BACKING MATERIAL</th>
<th>FIRESTOP DEPTH</th>
<th>FIRE RATING (HR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-1/4&quot;</td>
<td>4&quot; DIA.</td>
<td>NO</td>
<td>3/4&quot;</td>
<td>NONE OR FOAM</td>
<td>1-1/2&quot;</td>
<td>2</td>
</tr>
<tr>
<td>3-1/4&quot;</td>
<td>4&quot; DIA.</td>
<td>NO</td>
<td>3/4&quot;</td>
<td>3&quot; MINERAL MOUL</td>
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<td>2</td>
</tr>
<tr>
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<td>4&quot; DIA.</td>
<td>YES</td>
<td>3/4&quot;</td>
<td>NONE OR FOAM</td>
<td>1-1/2&quot;</td>
<td>2</td>
</tr>
<tr>
<td>3-1/4&quot;</td>
<td>4&quot; DIA.</td>
<td>YES</td>
<td>3/4&quot;</td>
<td>3&quot; MINERAL MOUL</td>
<td>1-1/2&quot;</td>
<td>2</td>
</tr>
<tr>
<td>3-1/4&quot;</td>
<td>4&quot; DIA.</td>
<td>NO</td>
<td>3/4&quot;</td>
<td>BACKER ROD OR FOAM</td>
<td>3/4&quot;</td>
<td>1</td>
</tr>
</tbody>
</table>
INSTRUCTIONS FOR INSTALLATION

STEP 1 - PREPARATION
ALL SURFACES SHOULD BE CLEAN, SOUND AND DRY. PRIOR TO APPLICATION OF FIRE-STOPPING MATERIALS, DO NOT REMOVE PIPE INSULATION.

STEP 2 - FIRE-STOP SEALANT
SEAL THE ANULAR SPACE AROUND THE PIPE WITH A 1/4" LAYER OF FIRE-STOP SEALANT.

STEP 3 - INTUMESCENT WRAP
MEASURE AND CUT ENOUGH INTUMESCENT WRAP TO COMPLETELY CIRCLE THE PIPE ONCE. WRAP IT SNUGLY AROUND THE PIPE. FOIL SIDE OUT BUTTING THE ENDS, AND TAPE IN PLACE USING WAX FIBER TAPE. INSTALL A SECOND LAYER OF WRAP IN THE SAME MANNER. SLIDE BOTH LAYERS UP THE PIPE, BUTTING THEM AGAINST THE SURFACE OF THE WALL OR CEILING. WALL PENETRATIONS REQUIRE A SYMMETRICAL SYSTEM ON BOTH SIDES.

STEP 4 - RETAINING COLLAR
MEASURE AND CUT ENOUGH RETAINING COLLAR TO ENCIRCLE THE INTUMESCENT WRAP AND OVERLAP THE ENDS APPROXIMATELY 1". BEND THE ANCHOR TABS OUTWARD 90 DEGREES. THEN PLACE THE COLLAR SNUGLY AROUND THE WRAP AND TIGHTEN IT WITH A SINGLE COLLAR CLAMP AT MID HEIGHT, FASTEN THE ANCHOR TABS TO THE SUBSTRATE USING 1/4" DIA. EXPANSION BOLTS. TO COMPLETE THE INSTALLATION, BEND THE SUPPORT TABS INWARD TOWARD THE PIPE.

NOTE: THIS DETAIL REPRESENTS ONE MANUFACTURER'S RECOMMENDATIONS FOR GENERAL USE. APPLICATIONS MAY VARY. THEREFORE, THE CONTRACTOR SHALL CONSULT THE FIRE-STOPPING MATERIALS MANUFACTURER FOR SPECIFIC INFORMATION AND INSTALLATION INSTRUCTIONS.

INSULATED METAL PIPE PENETRATION THRU RATED CONCRETE FLOOR OR WALL

FOR ALL NON-SBS JOBS
**Insulated Metal Pipe Penetration thru Rated Gypsum Wall**

Not to Scale

**FOR ALL NON-SBS JOBS**

---

### Design Guide Details

**University of Arkansas at Fayetteville**

**Date:** XXXXXX

**Sheet No.:** Det 85

---

**Instructions for Installation**

**Step 1 - Preparation**

All surfaces should be clean, sound, and dry prior to application of fire-stopping materials.

**Step 2 - Fire-Stop Sealant**

Seal the annular space around the pipe with a 1/4" layer of fire-stop sealant.

**Step 3 - Intumescent Wrap**

Measure and cut enough intumescent wrap to completely circle the pipe 3 times. Wrap it snugly around the pipe and secure in place using wrap tape or steel tie wire. Optionally, each layer of wrap may be cut to fit and held in place with wrap tape. Slide the wraps toward the opening and butt them against the wall.

**Step 4 - Retaining Collar**

Measure and cut enough retaining collar to encircle the intumescent wrap. Overlap the ends approx. 1", bend the anchor tabs outward 90°. Then place the collar snugly around the wrap so the anchor tabs are flush with the wall. Secure the collar with a single collar clamp at mid height. Then fasten the anchor tabs to the wall using screws or toggle bolts. Finally, bend the support tabs inward toward the pipe and seal them with a generous bead of fire-stop sealant.

---

**Table:**

<table>
<thead>
<tr>
<th>Pipe Type</th>
<th>Max. Pipe Dia.</th>
<th>Piping System</th>
<th>Annular Space</th>
<th>No. of Layers of Wrap</th>
<th>F* Rating (Hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulated Steel (See Note Below)</td>
<td>3”</td>
<td>V.G</td>
<td>1/4</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

* V = Vented Piping System (Process or Supply Piping)
  C = Closed Piping System (Drain, Waste, or Vent)

---

**Note:**

Maximum 3" diameter steel pipe with up to 1/4" insulation. This detail represents one manufacturer's recommendations for general use. Applications may vary, therefore the contractor shall consult the fire-stopping materials manufacturer for specific information and installation instructions.

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**TOP VIEW**

- **STEEL SLEEVE** (see table below)
- **SECTION A-A**
- **CONCRETE FLOOR** (for walls, see note 1)
- **1/2"-4" DIA. STEEL PIPE/CONDUIT**
- **BACKING MATERIAL** (see table below)

**INSTRUCTIONS FOR INSTALLATION**

**STEP 1 - PREPARATION**
All surfaces should be clean, sound and dry prior to application of firestopping materials.

**STEP 2 - BACKING MATERIAL FILL**
Fill around the pipe, leaving approx. space for the sealant & allow the foam to cure.

**STEP 3 - FIRESTOP SEALANT APPLY**
Required depth of firestop sealant apply required depth of firestop sealant & tool with putty knife until flush with the surface. Wall penetrations require sealant on both sides. Leave completed seal undisturbed for 48 hours.

<table>
<thead>
<tr>
<th>MINIMUM CONCRETE THICKNESS</th>
<th>MAX. SIZE PIPE/CONDUIT</th>
<th>STEEL SLEEVE</th>
<th>ANNULAR SPACE</th>
<th>BACKING MATERIAL</th>
<th>FIRESTOP DEPTH</th>
<th>FIRE RATING (HR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-1/4&quot;</td>
<td>4&quot; DIA.</td>
<td>NO</td>
<td>3/4&quot;</td>
<td>None or Foam</td>
<td>1-1/2&quot;</td>
<td>2</td>
</tr>
<tr>
<td>3-1/4&quot;</td>
<td>4&quot; DIA.</td>
<td>NO</td>
<td>3/4&quot;</td>
<td>3&quot; Mineral Wool</td>
<td>1/2&quot;</td>
<td>2</td>
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<tr>
<td>3-1/4&quot;</td>
<td>4&quot; DIA.</td>
<td>YES</td>
<td>3/4&quot;</td>
<td>None or Foam</td>
<td>1-1/2&quot;</td>
<td>2</td>
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<tr>
<td>3-1/4&quot;</td>
<td>4&quot; DIA.</td>
<td>YES</td>
<td>3/4&quot;</td>
<td>3&quot; Mineral Wool</td>
<td>1/2&quot;</td>
<td>2</td>
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<tr>
<td>3-1/4&quot;</td>
<td>4&quot; DIA.</td>
<td>NO</td>
<td>3/4&quot;</td>
<td>Backer Rod or Foam</td>
<td>3/4&quot;</td>
<td>1</td>
</tr>
</tbody>
</table>

**NOTES:**
1. In walls, install firestop system symmetrically on both sides.
2. If walls are masonry, min thickness = 8".

**NOTE:** This detail represents one manufacturer’s recommendations for general use. Applications may vary, therefore the contractor shall consult the fire-stopping materials manufacturer for specific information and installation instructions.

---

**METAL PIPE PENETRATION thru RATED CONCRETE FLOOR OR WALL**

Not to Scale

**FOR ALL NON-SBS JOBS**

---

University of Arkansas at Fayetteville
Design Guide Details
INSTRUCTIONS FOR INSTALLATION

STEP 1 - PREPARATION
ALL SURFACES SHOULD BE CLEAN, SOUND AND DRY PRIOR TO APPLICATION OF FIRESTOPPING MATERIALS.

STEP 2 - STEEL SLEEVE (OPTIONAL)
IF SLEEVE WILL NOT BE INSTALLED, SKIP TO STEP 3. IF A SLEEVE WILL BE INSTALLED, USE 25 GA. GALVANIZED SHEET METAL TO FORM A CYLINDER WITH MOUNTING FLANGES AS SHOWN ON THE DRAWING. ATTACH THE FLANGES WITH 4 DRYWALL SCREWS ON BOTH SIDES OF THE WALL.

STEP 3 - BACKING MATERIAL
WITHOUT SLEEVE
FIRMLY PACK MINERAL WOOL (MINIMUM DENSITY OF 4 LBS./CU.FT.) INTO THE OPENING TO A DEPTH OF 3". USE WRAP TAPE OR TIE WIRE TO KEEP MINERAL WOOL FROM FALLING INTO WALL CAVITY. LEAVE 1" SPACE ON BOTH SIDES OF THE WALL FOR FIRESTOP SEALANT.

WITH SLEEVE
FIRMLY PACK MINERAL WOOL INTO THE OPENING TO A DEPTH OF 4". LEAVE 1/2" SPACE ON BOTH SIDES OF THE WALL FOR FIRESTOP SEALANT.

STEP 4 - FIRESTOP SEALANT
APPLY A 1" DEPTH (1/2" IF SLEEVE WAS USED) OF FIRESTOP SEALANT OVER THE MINERAL WOOL ON BOTH SIDES OF THE WALL UNTIL FLUSH WITH THE WALL. TOOL WITH A PUTTY KNIFE FOR A SMOOTH APPEARANCE. LEAVE COMPLETE SEAL UNDISTURBED FOR 48 HOURS.

<table>
<thead>
<tr>
<th>PIPE DIA.</th>
<th>STEEL SLEEVE</th>
<th>ANNULAR SPACE (IN.)</th>
<th>MINERAL WOOL</th>
<th>CS 240 DEPTH</th>
<th>FIRE RATING (HRS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot;-4&quot;</td>
<td>YES</td>
<td>3/4</td>
<td>4&quot;</td>
<td>1/2&quot;</td>
<td>2</td>
</tr>
<tr>
<td>1/2&quot;-4&quot;</td>
<td>NO</td>
<td>3/4</td>
<td>3&quot;</td>
<td>1&quot;</td>
<td>2</td>
</tr>
</tbody>
</table>

NOTE: THIS DETAIL REPRESENTS ONE MANUFACTURER'S RECOMMENDATIONS FOR GENERAL USE. APPLICATIONS MAY VARY, THEREFORE THE CONTRACTOR SHALL CONSULT THE FIRESTOPPING MATERIALS MANUFACTURER FOR SPECIFIC INFORMATION AND INSTALLATION INSTRUCTIONS.

METAL PIPE PENETRATION thru RATED GYPSUM WALL
FOR ALL NON-SBS JOBS
PRE-INSULATED STEEL PIPE THROUGH WALL
NOT TO SCALE
CONTINUOUS BEAD OF RTV SILICONE
CONTINUOUS 1" WIDTH MASTIC SEALER
COUNTER FLASHING
NAILER
GRANULAR BASE FLASHING
3 PLY FIBERGLASS ROOF FELT SEALED WITH STEEP ASPHALT
PREFABRICATED EQUIPMENT CURB

RELIEF AIR HOOD
BIRD SCREEN
EXTENDED THROAT
REFER TO ARCHITECTURAL DRAWINGS FOR ROOF DETAILS
BAR JOIST
CONTROL DAMPER
SCREENED OPENING
TREATED WOOD BLOCKING
ROOF
INSULATED ROOF CURB

ELEVATOR HOISTWAY RELIEF VENT DETAIL
NOT TO SCALE
SIDE OF MAIN DUCT

CLOSE OPENING AT CORNERS

45°

W

1/4' MIN

0" x 1" NEOPRENE GASKET

VOLUME DAMPER WITH LOCKING QUADRANT

PROVIDE STAND-OFF DAMPER BRACKET ON INSULATED DUCTS

GALVANIZED HIGH EFFICIENCY TAKEOFF W/DAMPER AS MANUFACTURED BY SHEET METAL CONNECTORS, INC.
1-800-328-1966
SPIN-IN FITTINGS WITH SCOOPS ARE NOT ACCEPTABLE

SEE PLANS FOR RUNOUT SIZES

MANUAL BALANCING DAMPER
NOT TO SCALE

University of Arkansas at Fayetteville
Design Guide Details
VERTICAL FAN COIL UNIT PIPING DETAIL

NOT TO SCALE
FURNISH AND INSTALL A TWO RICH DEEP OVERFLOW DRAIN PAN UNDER EACH FAN COIL UNIT. PAN DIMENSIONS SHALL BE SIX INCHES GREATER THAN THE FAN COIL FOOTPRINT (INCLUDING AUXILIARY DRAIN PAN).

CONNECT A SEPARATE 1-1/4" CONDENSATE DRAIN LINE TO OVERFLOW PAN AND ROUTE TO A CONSPICUOUS LOCATION DESIGNATED ON FLOOR PLANS, LABEL PIPE AS "CONDENSATE OVERFLOW DRAIN LINE".

HORIZONTAL FAN COIL UNIT PIPING DETAIL
NOT TO SCALE
HEATING ONLY FAN COIL UNIT PIPING DETAIL

NOT TO SCALE
Furnish and install a 1/2" inch deep overflow drain pan under each fan coil unit. Pan dimensions shall be six inches greater than the fan coil footprint including auxiliary drain pan.

Connect a separate 1-1/4" condensate drain line to overflow pan and route to a conspicuous location designated on floor plans. Label pipe as "condensate overflow drain line".
HEATING ONLY FAN COIL UNIT PIPING DETAIL

AUTOMATIC CONTROL VALVE
FLOW LIMITING VALVE
HEATING WATER RETURN
CONCENTRIC REDUCER
ECCENTRIC REDUCER
HEATING WATER SUPPLY
GATE OR BALL VALVE
STRAINER W/ HOSE ADAPTER
DRAIN VALVE
MANUAL AIR VENT
P & T PLUG
UNION
TWO ROW HEATING COIL
PRIMARY DRAIN PAN
COOLING ONLY FAN COIL UNIT PIPING DETAIL

FURNISH AND INSTALL A TWO INCH DEEP OVERFLOW DRAIN PAN UNDER EACH FAN COIL UNIT. PAN DIMENSIONS SHALL BE SIX INCHES GREATER THAN THE FAN COIL FOOTPRINT (INCLUDING AUXILIARY DRAIN PAN).

CONNECT A SEPARATE 1-1/4" CONDENSATE DRAIN LINE TO OVERFLOW PAN AND ROUTE TO A CONSPICUOUS LOCATION DESIGNATED ON FLOOR PLANS. LABEL PIPE AS "CONDENSATE OVERFLOW DRAIN LINE".
FURNISH AND INSTALL A TWO INCH DEEP OVERFLOW DRAIN PAN UNDER EACH FAN COIL UNIT. PAN DIMENSIONS SHALL BE SIX INCHES GREATER THAN THE FAN COIL FOOTPRINT (INCLUDING AUXILIARY DRAIN PAN).

CONNECT A SEPARATE 1-1/4" CONDENSATE DRAIN LINE TO OVERFLOW PAN AND ROUTE TO A CONSPICUOUS LOCATION DESIGNATED ON FLOOR PLANS. LABEL PIPE AS "CONDENSATE OVERFLOW DRAIN LINE".

COOLING ONLY FAN COIL UNIT PIPING DETAIL

NOT TO SCALE
ROOFTOP UPBLAST EXHAUST FAN (KITCHEN DETAIL)

NOT TO SCALE
ROOFTOP DOWNBLAST EXHAUST FAN DETAIL

NOT TO SCALE
ROOFTOP UPBLAST EXHAUST FAN (KITCHEN DETAIL)

NOT TO SCALE
EXPANSION LOOP DETAIL
NOT TO SCALE
Air Eliminator Detail

Automatic Air Vent

Manual or Hand Operated Air Vent

SARCO 13 WS
ARMSTRONG NO 1-AV
WHEATLEY AR 0075

3/4" Ball Valve

Check Valve

Union

1/4" NPS

1/4" Ball Valve Locate in Accessible Position

Not to Scale

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Design Guide Details
AIR CONTROL PIPING DETAIL

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Design Guide Details
WATER HEATER DETAIL

ASME RATED T&P RELIEF VALVE

3/4" HEAT TRAP

BALL VALVE (TYPICAL)

DELECTRIC UNION (TYPICAL)

MATS MODEL # I LT-5 IN-LINE EXPANSION TANK

3/4" DOWN TO JANITOR SINK

3/4" HEAT TRAP

SAFETY CABLE

BLOCK MALL

AUXILIARY DRAIN PAN

3"x3"x1/4" ANGLE IRON WELDED PLATFORM

3/4" x 24" x 0.25" THICK STEEL PLATE, TYPICAL 2

1/2" x 5" BOLTS, GRADE 5, TYPICAL 6

3" x 3" x 1/4" ANGLE IRON WELDED FRAME

3/8" NPT CONN

30"

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Design Guide Details
REFER TO ARCHITECTURAL DRAWINGS FOR TYPE OF STRUCTURE

3/4" HW

3/4" CW

30"

HEAT TRAP

WATTS MODEL # ILT-5 IN-LINE EXPANSION TANK

HOLDRITE "EZ-STRUT" ALL-THREAD ROD WITH LOAD RATING OF 500 LBS (TYPICAL OF 4)

HUBBARD "QUICK STAND" MODEL #40-SWHP WATER HEATER PLATFORM / DRAIN PAN

WATER HEATER NH-1

BALL VALVE (TYPICAL)

DI-ELECTRIC UNION (TYPICAL)

ASME RATED T&P RELIEF VALVE

CROSS BRACING FURNISHED WITH PLATFORM / DRAIN PAN

TANK DRAIN WITH HOSE BIBB CONNECTION

3/4"

1" DRAIN FROM WATER HEATER PLATFORM / DRAIN PAN

1" DRAIN TO FLOOR DRAIN

WATER HEATER DETAIL

SCALE: NONE

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WATER HEATER DETAIL

SCALE: NONE
DOMESTIC WATER HEATER DETAIL 4 RETURN
CONTROL VALVE W/ TEMPERATURE SENSOR

NOT TO SCALE

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Design Guide Details
Exterior piping shall be insulated and covered with aluminum jacket.

16 gauge sleeve 12" long

2" schedule 40 pipe support

Cellular glass high density insulation between pipe and saddle, one third of circumference

Continuous weld

Drop sleeve anchors 3/8" minimum bolt dia.

Concrete

8"x8"x3/8" steel base plate

Pipe Stanchion Detail

Not to scale
EXTERIOR PIPING SHALL BE INSULATED AND COVERED WITH ALUMINUM JACKET

16 GAUGE SLEEVE 12" LONG

2" SCHEDULE 40 PIPE SUPPORT

CELLULAR GLASS HIGH DENSITY INSULATION BETWEEN PIPE AND SADDLE, ONE THIRD OF CIRCUMFERENCE

CONTINUOUS WELD

DROP SLEEVE ANCHORS 3/8" MINIMUM BOLT DIA.

CONTINUOUS WELD

CONCRETE

8"x8"x3/8" STEEL BASE PLATE

PIPE STANCHION DETAIL

NOT TO SCALE
A.S.M.E. RELIEF VALVE

RELIEF LINE TO FLOOR DRAIN
REFER TO PLANS FOR ROUTING
OF RELIEF LINE

WATER RELIEF VALVE DETAIL
NOT TO SCALE
FLANGED END SUCTION PUMP
with INERTIA BASE PIPING DETAIL

1/4" Type L Hard Drawn Copper or SCH. 40 Black Steel Gauge piping with 1/4" Ball Valves

Flanged SUCTION DIFFUSER w/ built-in strainer Diffuser Inlet Equal to pipe size Diffuser Outlet equal to pump inlet size

Route 3/4" Drain Line to Floor Drain 1" Pipe Stand

Concrete Inertia Pad, coordinate location of anchor bolts with pump base dimensions

Steel Pipe drill pipe & install 1/4" thread-o-let for gauge & P-T fittings

Flanged WAFFER CHECK VALVE

Flanged CONCENTRIC INCREASE PUMP OUTLET DIAMETER BY PIPE SIZE

Flanged FLEXIBLE CONNECTOR CONNECTOR SIZE EQUAL TO PUMP OUTLET

END SUCTION PUMP w/ Flanged Connections

1/4" Type L Hard Drawn Copper or SCH. 40 Black Steel Gauge piping with 1/4" Ball Valves

Pressure gauge

P & T Plug

Two (2) Weld Neck Spacer Flanges

Split Disk Check Valve

Gear Operated Butterfly Valve w/ Dial Indicator and Handwheel

Gear Operated Butterfly Valve w/ Dial Indicator and Handwheel

Inlet Pipe Diameter refer to plan view

Outlet Pipe Diameter refer to plan view

Drain Pan

Floor Flange

University of Arkansas at Fayetteville Design Guide Details
INLET PIPE DIAMETER
REFER TO PLAN VIEW

STEEL PIPE
DRILL PIPE & INSTALL
1/4" THREAD-O-LET FOR
GAUGE & P-T FITTINGS

GATE OR BALL VALVE

COPPER PIPE
SIL-FOS FEMALE
ADAPTER BEFORE
DRILLING PIPE

1/4" NPT FOR GAUGES
AND P-T FITTINGS.
INSTALL CONTINUATION
PIPING FOR GAUGES
WITH COPPER TO H.S.P.S.
ADAPTOR.

COPPER TO F.S.P.S.
FEMALE ADAPTER.

THREAD FLEXIBLE CONNECTOR
SIZE EQUAL TO DIFFUSER INLET

THREAD SUCTION DIFFUSER W/ BUILT-IN
STRAINER DIFFUSER INLET EQUAL TO PIPE
SIZE DIFFUSER OUTLET EQUAL TO
PUMP INLET

ROUTE 3/4" DRAIN LINE TO FLOOR DRAIN

3/4" PIPE STAND

FLOOR FLANGE

DRAIN PAN

CONCRETE HOUSEKEEPING PAD
FIELD VERIFY BASE DIMS & HT
BASE MOUNTED END SUCTION PUMP

NOTE: DO NOT INSTALL ALL THREAD NIPPLES

BASE MOUNTED END SUCTION PUMP PIPING DETAIL
NOT TO SCALE
CONDENSATE RETURN PUMP PIPING DETAIL

NOT TO SCALE

University of Arkansas at Fayetteville
Design Guide Details
STEAM RELIEF VALVE W/ DRIP PAN ELBOW DETAIL

NOT TO SCALE

<table>
<thead>
<tr>
<th>DESIGNATION</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
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<tbody>
<tr>
<td>RELIEF VALVE (RV-1)</td>
<td>3/4″</td>
<td>1/2″</td>
<td>3/4″</td>
<td>1″</td>
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</table>
Steam Relief Valve with Drip Pan Elbow Detail

**Design Guide Details**

<table>
<thead>
<tr>
<th>DESIGNATION</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
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<td>Relief Valve (RV-1)</td>
<td>3/4&quot;</td>
<td>1/2&quot;</td>
<td>3/4&quot;</td>
<td>1&quot;</td>
</tr>
</tbody>
</table>

TERMINE MINIMUM 6'-0" ABOVE ROOF

SUPPORT FROM BUILDING STRUCTURE

"D" DISCHARGE RISER

DRIP PAN ELBOW

"A" PIPE NIPPLE

"B" DRAIN TO FLOOR DRAIN

"C" DRAIN TO FLOOR DRAIN

University of Arkansas at Fayetteville
Design Guide Details
DOMESTIC WATER HEATER/STORAGE TANK DETAIL

NOT TO SCALE
EXPANSION TANK, THERM-X-TROL MODEL ST-12.

ASME T&P RELIEF VALVE PIPE FULL LINE SIZE TO FLOOR DRAIN (TYPICAL)

80 GALLON STORAGE TANK

3/4" TO FLOOR DRAIN

DOMESTIC WATER HEATER DETAIL

SCALE: NONE
DOMESTIC WATER HEATER DETAIL & RETURN
CONTROL VALVE W/ TEMPERATURE SENSOR
NOT TO SCALE
**Domestic Water Heater Detail**

- ** Coordination with controls contractor for temperature sensor.
- ** Expansion tank, Therm-X-Trol model ST-12.**
- ** Tempering valve.**
- ** 2" HN.**
- ** 4" concrete housekeeping pad.**
- ** 100 gallon storage 149,000 BTU.**
- ** 3/4" hot water return.**
- ** 2" PVC flue thru roof.**
- ** 2" CM.**
- ** 2" HN.**
- ** 2" PVC combustion air intake.**
- ** Roof.**
- ** Counter flashing.**
- ** Flashing collar.**
- ** Sleeves.**
- ** 140° to dishwasher booster heater.**
- ** 110° to kit fixtures & toilets.**
- ** 3/4" to kit.**

---

**University of Arkansas at Fayetteville Design Guide Details**
DOMESTIC WATER HEATER DETAIL

SCALE: NONE

3/4" to Floor Drain
4" Concrete Housekeeping Pad

120 Gallon Storage Tank

TANK THERMOSTAT
1-1/4" HIN SUPPLY

THERMOMETER (TYPICAL)

ASME P&T RELIEF VALVE, PIPE FULL SIZE TO FLOOR DRAIN

EXPANSION TANK, THERM-X-TROL MODEL ST-12.

30" HEAT TRAP

?" COPPER FLUE

?" COPPER FLUE

UNION (TYPICAL)

BALL VALVE (TYPICAL)

HWRP=1

?" HWR

?" CW

CHECK VALVE (TYPICAL)
DOMESTIC WATER HEATER DETAIL

SCALE: NONE
3/4" T & P RELIEF TO OUTSIDE OF EXTERIOR WALL

BALL VALVE (TYPICAL)

WATER HEATER WH-2 BELOW VANITY COUNTERTOP

1/2" CW AND HW TO SINK S-1 AT BOARD CATERING

1/2" CW AND HW IN STUD WALL UP TO CEILING SPACE

1/2" CW AND HW IN STUD WALL BEHIND FINISHED WALL

UNION (TYPICAL)
DOMESTIC WATER HEATER DETAIL & RETURN PUMP DETAIL

NOT TO SCALE

University of Arkansas at Fayetteville
Design Guide Details
KEYED NOTES
1. Flash Tank - Equals Wood Industrial Products Co.
2. Perforated Inlet Pipe
3. Drop Tube
4. 4" x 6" Hand Hole
5. 2" Return Header, Taps As Required
6. Medium and High Pressure Steam Condensate Returns
7. 1" Drain Valve
8. Float & Thermostatic Steam Trap
9. To Condensate Return Unit
10. 2" Vent Thru Roof

FLASH TANK PIPING DETAIL
NOT TO SCALE
KEYED NOTES

1. FLASH TANK - EQUAL TO WENDLEND CORPORATION MODEL FT-15
   12" DIAMETER, 30' LENGTH, 15 GALLON CAPACITY
2. 18" LONG PERFORATED INLET PIPE w/ (18) 1/4" DIA HOLES
3. 2" OUTLET
4. 1/4" RETURN HEADER, TAPS AS REQUIRED
5. MEDIUM AND HIGH PRESSURE STEAM CONDENSATE RETURNS
6. 1" DRAIN VALVE
7. FLOAT & THERMOSTATIC STEAM TRAP
8. TO CONDENSATE RETURN UNIT
9. 2" VENT THRU ROOF

FLASH TANK PIPING DETAIL

NOT TO SCALE
INLET PIPE DIAMETER
REFER TO PLAN VIEW

STEEL PIPE
DRILL PIPE & INSTALL
1/4" THREAD-O-LET FOR
GAUGE & P-T FITTINGS

GATE OR BALL VALVE

COPPER PIPE
SIL-FOG FEMALE ADAPTER BEFORE
DRILLING PIPE
1/4" NPT FOR GAUGES
AND P-T FITTINGS.
INSTALL CONTINUATION
PIPING FOR GAUGES
WITH COPPER TO M.S.P.S.
ADAPTER.
COPPER TO F.S.P.S.
PUMPMATE ADAPTER.

THREAD FREE CONNECTOR
SIZE EQUAL TO DIFFUSER INLET

THREAD SUCTION DIFFUSER W/ BUILT-IN
STRAINER DIFFUSER INLET EQUAL TO PIPE SIZE
DIFFUSER OUTLET EQUAL TO PUMP INLET

ROUTE 3/4" DRAIN LINE TO FLOOR DRAIN
3/4" PIPE STAND
FLOOR FLANGE

DRAIN PAN
CONCRETE HOUSEKEEPING PAD,
FIELD VERIFY BASE DIMS & HT
BASE MOUNTED END SUCTION PUMP

OUTLET PIPE DIAMETER
REFER TO PLAN VIEW

GATE OR BALL VALVE
P & T Plug

CHECK VALVE

THREADED MALE NIPPLE

THREADED FLEXIBLE CONNECTOR
CONNECTOR SIZE EQUAL TO PIPE SIZE

UNION

1/4" TYPE I HARD DRAWN COPPER
OR SCH. 40 BLACK STEEL GAUGE PIPING

THREADED CONCENTRIC INCREASER
PUMP OUTLET DIAMETER BY PIPE SIZE

NOTE: DO NOT INSTALL ALL THREAD NIPPLES

BASE MOUNTED END SUCTION
PUMP PIPING DETAIL
NOT TO SCALE
FLANGED END SUCTION PUMP w/ INERTIA BASE PIPING DETAIL

NOT TO SCALE
COOLING TOWER CHEMICAL TREATMENT SYSTEM PIPING DIAGRAM

NOT TO SCALE

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Design Guide Details
CHEMICAL TREATMENT SYSTEM PIPING DIAGRAM

University of Arkansas at Fayetteville
Design Guide Details
NOTE:
FLEXIBLE DUCT CONNECTIONS SHALL BE INSTALLED TO ADC STANDARDS AND SEALED TO UL STANDARDS PER AMC 603 AND 604.2.I. AS A MINIMUM, THE CONTRACTOR SHALL SECURE THE FLEXIBLE DUCT TO GRILLE AND METAL DUCT WITH DRAWBANDS, AND WRAP 3" WIDE ALUMINUM TAPE EQUAL TO HARDCAST "FOIL GRIP" AROUND DRAWBAND AND EXPOSED END OF FLEXIBLE DUCT INSULATION.
NOTE:
FLEXIBLE DUCT CONNECTIONS SHALL BE INSTALLED TO ADC STANDARDS AND SEALED TO UL STANDARDS PER AMC 603 AND 604.2.1. AS A MINIMUM, THE CONTRACTOR SHALL SECURE THE FLEXIBLE DUCT TO ENDS OF METAL DUCT WITH DRAWBANDS, AND WRAP 3'' WIDE ALUMINUM TAPE EQUAL TO HARDCAST "FOIL GRIP" AROUND DRAWBAND AND EXPOSED END OF FLEXIBLE DUCT INSULATION.
SAFETY HANGER FOR GRILLE-SECURE 12 GA WIRE OR 10 GA X 1" WIDTH METAL STRAP FROM DIFFUSER TO STRUCTURE. TWO REQ. REFER TO DETAIL FOR ATTACHMENT TO STRUCTURE.

VAPOR SEAL STRAP PENETRATION

FLEXIBLE DUCT (MAX. LENGTH - 5'-0"")

DRAWBAND

DRAWBAND

ROUND NECK DIFFUSER

SECURE EDGE OF INSULATION TO T-BAR GRID WITH ALUMINUM TAPE

CEILING

ROUND PIPE DUCT

BALANCING DAMPER PROVIDE EXTENSION FOR HANDLE TO CLEAR INSULATION

STREAMLINE TAP

DUCT STRAP SUPPORT WRAP AROUND DUCT AND SECURE TO STRUCTURE

DUCT WRAP W/ VAPOR BARRIER

NOTE:
FLEXIBLE DUCT CONNECTIONS SHALL BE INSTALLED TO ADC STANDARDS AND SEALED TO UL STANDARDS PER AMC 603 AND 604.2. AS A MINIMUM, THE CONTRACTOR SHALL SECURE THE FLEXIBLE DUCT TO GRILLE AND METAL DUCT WITH DRAWBANDS, AND WRAP 3" WIDE ALUMINUM TAPE EQUAL TO HARDCAST "FOIL GRIP" AROUND DRAWBAND AND EXPOSED END OF FLEXIBLE DUCT INSULATION.

DIFFUSER CONNECTION TO ROUND DUCT

NOT TO SCALE

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Design Guide Details
3/8" DIAMETER DRILL-IN EXPANSION ANCHOR

STEEL STRAP 1" W x 2" L x 12 GA. MINIMUM

45°

1-1/2"

FOUR (4) TIGHT TURNS

SPLAYED SEISMIC BRACING WIRE

BRACING WIRE ATTACHMENT DETAIL
NOT TO SCALE
**NOT TO SCALE**

**SIDE BRACING FOR RECTANGULAR DUCT DETAIL**

When a combination of ducts is used in lieu of one duct, at least two sides of each duct must be connected to vertical or horizontal angles and the combined height shall not exceed that given in the tables in Chapter 5 of SMACNA's "Seismic Restraint Guidelines for Mechanical Systems."
NOTE:

WHEN A COMBINATION OF DUCTS IS USED IN LIEU OF ONE DUCT, AT LEAST TWO SIDES OF EACH DUCT MUST BE CONNECTED TO VERTICAL OR HORIZONTAL ANGLES AND THE COMBINED WEIGHT SHALL NOT EXCEED THAT GIVEN IN THE TABLES IN CHAPTER 5 OF SMACNA'S "SEISMIC RESTRAINT GUIDELINES FOR MECHANICAL SYSTEMS".

**SIDE BRACING FOR RECTANGULAR DUCT DETAIL**

_NOT TO SCALE_
CENTER BRACING FOR RECTANGULAR DUCT DETAIL

NOTE:
When a combination of ducts is used in lieu of one duct, at least two sides of each duct must be connected to vertical or horizontal angles, and the combined height shall not exceed that given in the tables in Chapter 5 of SMACNA's "Seismic Restraint Guidelines for Mechanical Systems".

DATE:  
SHEET  
Sheet 1 of 1
DOUBLE HANGER BRACING FOR ROUND DUCT DETAIL

VERTICAL HANGER
TRANSVERSE BRACE
CENTERLINE OF BOLT EQUALS CENTERLINE OF ANGLE
2-1/2" x 12 GAUGE STRAP
3" x 3" x 3/16 PLATE WASHER

1 MIN 2 MAX
1-5/8"

VERTICAL HANGER
LONSTIDUAL BRACE
TRANSVERSE BRACE
MACHINE BOLTS
2-1/2" x 12 GAUGE STRAP
3" x 3" x 3/16 PLATE WASHER

8'-0" MAXIMUM TO TO STRUCTURAL SUPPORTING MEMBER

REFER TO DETAIL FOR CONNECTION TO SUPPORTING STRUCTURAL MEMBER (TYPICAL)
ANCHOR CONNECTION DETAIL

NOT TO SCALE

University of Arkansas at Fayetteville
Design Guide Details
### Anchor Connection Detail

NOT TO SCALE

<table>
<thead>
<tr>
<th>TYPE</th>
<th>Maximum Load Capacity (LBS)</th>
<th>Expansion Anchors to Concrete 'X'</th>
<th>Spreader Size</th>
<th>Machine Bolt at End of Brace</th>
<th>Distance of Bolt to Angle 'Y'</th>
<th>Angle to Supporting Structural Member</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1586</td>
<td>2 - 1/2&quot;</td>
<td>C5x6.1</td>
<td>1/2&quot;</td>
<td>3&quot;</td>
<td>2 - 4x3x3/8 BY 4&quot; LLH</td>
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<tr>
<td>B</td>
<td>2020</td>
<td>2 - 5/8&quot;</td>
<td>C6x8.5</td>
<td>1/2&quot;</td>
<td>3-3/4&quot;</td>
<td>2 - 5x3x3/8 BY 4&quot; LLH</td>
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<tr>
<td>C</td>
<td>2870</td>
<td>2 - 3/4&quot;</td>
<td>C8x11.5</td>
<td>5/8&quot;</td>
<td>4-1/2&quot;</td>
<td>2 - 6x3-1/2x3/8 BY 4&quot; LLH</td>
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</table>
ANCHOR CONNECTION DETAIL

NOT TO SCALE

<table>
<thead>
<tr>
<th>TYPE</th>
<th>MAXIMUM LOAD CAPACITY (LBS)</th>
<th>EXPANSION ANCHORS TO CONCRETE &quot;X&quot;</th>
<th>SPREADER SIZE</th>
<th>MACHINE BOLT AT END OF BRACE</th>
<th>DISTANCE OF BOLT TO ANGLE &quot;Y&quot;</th>
<th>ANGLE TO SUPPORTING STRUCTURAL MEMBER</th>
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<tbody>
<tr>
<td>F</td>
<td>4600</td>
<td>4 - 5/8&quot;</td>
<td>C9x13.4</td>
<td>3/4&quot;</td>
<td>3-3/4&quot;</td>
<td>2 - 5x3x3/8 BY 10&quot; LLH</td>
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<td>G</td>
<td>7040</td>
<td>4 - 3/4&quot;</td>
<td>C10x15.3</td>
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<td>2 -6x3-1/2x1/2 BY 11-1/2&quot; LLH</td>
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<tr>
<td>H</td>
<td>9240</td>
<td>4 - 1/8&quot;</td>
<td>C12x20.1</td>
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<td>5-1/4&quot;</td>
<td>2 - 8x4x3/4 BY 13-1/2&quot; LLH</td>
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</tbody>
</table>
BRACE CONNECTIONS to STEEL

NOT TO SCALE
Refer to detail for connection to supporting structural member (typical).

Typical Hangers

Effective hanger length for square duct

Alternate hanger location may be used to reduce the effective hanger length only if all hangers in the duct run are of a similar length.

Note:

Where bracing is omitted due to the 12" exception, the effective hanger length must be less than 12" as shown below. A snug fit to the beam does not meet this requirement.

Ducts hung below steel beams detail

Not to scale
VORTEX SPLITTER: FLOW METER DETAIL

NOT TO SCALE

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Design Guide Details
Chemical Feeder Piping Detail

Not to Scale
SEISMIC BRACING FOR AIR TERMINAL
NOT TO SCALE
2" x 1/8" plate washer attached to structure
Anchor bolt
Galvanized heavy wire rope thimble
Wire rope clips
3/8" dia. wire rope in 850 lb. breaking strength each corner

3" x 1/4" bent plate
3/8" dia. all-threaded rod

3/8" dia. all-threaded rods each corner. Refer to detail 1 table for stiffener requirements

Washer rod diameter "A"
Maximum length w/o rod stiffener "B"
Max. spacing between washer rod stiffener assembly "C"

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Length</th>
<th>Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8&quot; - 16</td>
<td>12&quot;</td>
<td>15&quot;</td>
</tr>
</tbody>
</table>

Provide flexible connection or swing joint unless pipe is also braced

3" x 3" x 1/4" angle
4# self-tapping sheet metal screws at 12" O.C. (2 minimum each angle)

3" x 3" x 1/4" angle

Seismic bracing for air terminal
Not to scale
DAMPER ACTUATOR SPECIFIED IN SECTION 15400
REFER TO CONTROL SCHEMATICS FOR TYPE

HIGH VELOCITY SUPPLY AIR DUCTWORK REFER
TO FLOOR PLANS AND SCHEDULES FOR SIZES

FLEXIBLE AIR DUCT
MAXIMUM LENGTH 3'-0"

TRANSITION AS REQUIRED
METAL DUCT CONNECTION TO AIR TERMINAL

AVERAGING VELOCITY SENSOR

AIR TERMINAL IDENTIFICATION TAG
AND BALANCING INFORMATION

AIR TERMINAL CONTROLLER SPECIFIED
IN SECTION 15400, MOUNT CONTROLLER
IN AN ACCESSIBLE LOCATION.

REFER TO FLOOR PLANS & CONTROL
SCHEMATICS FOR TYPE OF CONTROL
VALVE, MOUNT CONTROL VALVE IN
AN ACCESSIBLE LOCATION

RETURN

SUPPLY

LOW VELOCITY SUPPLY AIR
DUCTWORK REFER TO FLOOR
PLANS & SCHEDULES FOR
SIZES

TRANSITION AS REQUIRED

HEATING WATER REHEAT COIL

REFER TO DETAIL FOR PIPING
CONNECTIONS TO AIR TERMINAL

REFER TO SEISMIC BRACING DETAIL

TYPICAL AIR TERMINAL DETAIL
NOT TO SCALE
Typical Air Terminal Detail

1. Damper actuator specified in Section 15900, refer to control schematics for type.
2. High velocity supply air ductwork refer to floor plans and schedules for sizes.
3. Flexible air duct maximum length 3'-0".
4. Transition as required.
5. Metal duct connection to air terminal.
6. Averaging velocity sensor.
7. Air terminal identification tag and balancing information.
8. Air terminal controller specified in Section 15900, mount controller in an accessible location.
9. Low velocity supply air ductwork refer to floor plans & schedules for sizes.
10. Electric heating coil.
11. Transition as required.
12. Heating coil control panel provide adequate clearance for service & maintenance.
13. Refer to seismic bracing detail.

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IN-LINE EXHAUST FAN DETAIL
NOT TO SCALE

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Design Guide Details
NOTE:
REFER TO SPECIFICATIONS FOR THE MAXIMUM TRANSVERSE SUPPORT SPACING, MAXIMUM LONGITUDINAL SUPPORT SPACING AND MINIMUM HANGER ROD DIAMETER
<table>
<thead>
<tr>
<th>HANGER ROD DIAMETER 'A'</th>
<th>MAXIMUM LENGTH WITHOUT ROD STIFFENER 'B'</th>
<th>MAX. SPACING BETWEEN HANGER ROD STIFFENER ASSEMBLY 'C'</th>
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<tbody>
<tr>
<td>3/8&quot; - 16</td>
<td>14&quot;</td>
<td>13&quot;</td>
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<tr>
<td>1/2&quot; - 13</td>
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<td>7/8&quot; - 9</td>
<td>43&quot;</td>
<td>33&quot;</td>
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</table>

NOTE:
REFER TO SPECIFICATIONS FOR THE MAXIMUM TRANSVERSE SUPPORT SPACING, MAXIMUM LONGITUDINAL SUPPORT SPACING AND MINIMUM HANGER ROD DIAMETER

**CLEVIS HANGER TRANSVERSE BRACING DETAIL**

NOT TO SCALE
SECTION A-A

<table>
<thead>
<tr>
<th>HANGER ROD DIAMETER &quot;A&quot;</th>
<th>MAXIMUM LENGTH W/O ROD STIFFENER &quot;B&quot;</th>
<th>MAX. SPACING BETWEEN HANGER ROD STIFFENER ASSEMBLY &quot;C&quot;</th>
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<td>7/8&quot; - 9</td>
<td>43&quot;</td>
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</table>

NOTE:
REFER TO SPECIFICATIONS FOR THE MAXIMUM TRANSVERSE SUPPORT SPACING,
MAXIMUM LONGITUDINAL SUPPORT SPACING AND MINIMUM HANGER ROD DIAMETER

CLEVIS HANGER TRANSVERSE BRACING DETAIL
NOT TO SCALE

University of Arkansas at Fayetteville
Design Guide Details
NOTE: REFER TO SPECIFICATIONS FOR THE MAXIMUM TRANSVERSE SUPPORT SPACING, MAXIMUM LONGITUDINAL SUPPORT SPACING AND MINIMUM HANGER ROD DIAMETER.

### PIPE CLAMP TRANSVERSE BRACING DETAIL

**NOT TO SCALE**
PIPE LONGITUDINAL BRACING DETAIL

NOT TO SCALE

University of Arkansas at Fayetteville
Design Guide Details
<table>
<thead>
<tr>
<th>ANCHOR DIAMETER 'A'</th>
<th>MINIMUM EMBEDMENT OF ANCHOR 'B'</th>
<th>MIN. DISTANCE FROM EDGE OF CONCRETE 'C'</th>
<th>MAXIMUM LOAD (LBS)</th>
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</thead>
<tbody>
<tr>
<td>3/8&quot;</td>
<td>2-1/2&quot;</td>
<td>4&quot;</td>
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<td>7&quot;</td>
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<tr>
<td>3/4&quot;</td>
<td>4-3/4&quot;</td>
<td>8&quot;</td>
<td>850</td>
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</table>

**BRACING ATTACHMENT to CONCRETE DETAIL**

**NOT TO SCALE**
**Bracing Attachment to Concrete Detail**

**NOT TO SCALE**

<table>
<thead>
<tr>
<th>Anchor Diameter 'A'</th>
<th>Minimum Embedment of Anchor 'B'</th>
<th>Min. Distance from Edge of Concrete 'C'</th>
<th>Min. Distance Between Anchors 'D'</th>
<th>Maximum Load (Lbs)</th>
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<tbody>
<tr>
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<tr>
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<td>4-3/4&quot;</td>
<td>8&quot;</td>
<td>9&quot;</td>
<td>1200</td>
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</tbody>
</table>
BRACING ATTACHMENT to STEEL STRUCTURE

NOT TO SCALE
**KEYED NOTES:**

1. THREAD-O-LET, CLASS 3000 FORGED STEEL WITH 2" +/- NIPPLE. 
   (HOLD DRAIN LINE CLOSE TO MAIN ALLOWING FOR BOTH MAIN AND DRAIN LINE INSULATION AND A SLIGHT GAP BETWEEN THE TWO).

2. ALL PIPING TO BE SCH 80, THREADED FITTINGS TO BE CLASS 300 MALLEABLE IRON.

3. STAINLESS STEEL BALL VALVE EQUAL TO APOLLO SERIES 76F-100 WITH LOCKING LEVER HANDLE.

4. INSULATE DRAIN LINE WITH FLEXIBLE CLOSED CELL ELASTOMERIC FROM VALVE BACK TO MAIN PIPE. SEAL TO MAIN PIPE INSULATION.

5. ORIENT VALVE HANDLE IN VERTICAL PLANE, WITH CLOSED BEING IN THE UP POSITION, SO GRAVITY HOLDS HANDLE LOCK IN "LOCKED" POSITION, HANDLE TO FACE AISLE.

**ELEVATION**

**PLAN**

**MAIN LINE / LARGE SERVICE DRAINS**

**CHILLED & HEATING HOT WATER**

**NOT TO SCALE**
KEYED NOTES

1. 1" THREAD-O-LET CLS 3000, FORGED STEEL.
2. ALL LINE SIDE PIPE TO BE SCH 80, THREADED FITTINGS TO BE CLS 300, MALLEABLE IRON.
3. 1" STAINLESS STEEL BALL VALVE EQUAL TO APOLLO SERIES 76F-100.
4. 1" THREADED TEE, CLS 300 MALLEABLE IRON.
5. SCH 80 NIPPLE.
6. 1" X 1/2" FORGED STEEL BUSHING.
7. 1/2" STAINLESS STEEL BALL VALVE EQUAL TO APOLLO SERIES 76F-100, HANDLE TO FACE AISLE.
8. 1/2" AUTOMATIC AIR VENT.
9. PIPE TO FLOOR DRAIN WITH 1/2" SCH 40 PIPE, THREADED FITTINGS TO BE CLS 150, MALLEABLE IRON.
10. PROVIDE PIPE SUPPORT FOR ASSEMBLY, HELD TO MAIN.
11. AIR POCKET.

<table>
<thead>
<tr>
<th>AIR POCKET SIZE</th>
<th>PIPE SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>FULL PIPE SIZE</td>
<td>4&quot; AND SMALLER</td>
</tr>
<tr>
<td>4&quot;</td>
<td>6&quot; AND 8&quot;</td>
</tr>
<tr>
<td>6&quot;</td>
<td>10&quot; AND LARGER</td>
</tr>
</tbody>
</table>

12. IN PLAN VIEW, ROTATE VENT ASSEMBLY PARALLEL WITH MAIN PIPE RUN TO MINIMIZE CONFLICT WITH AISLE.
13. INSULATE AIR VENT LINE WITH FLEXIBLE CLOSED CELL ELASTOMERIC INSULATION FROM VALVE BACK TO MAIN PIPE. SEAL TO MAIN PIPE INSULATION.
14. INSULATE PIPE SUPPORTS WITH FLEXIBLE CLOSED CELL ELASTOMERIC INSULATION UP TO PIPING TO PREVENT CONDENSATION FORMING AT THE SUPPORTS.

MAIN LINE / LARGE SERVICE AIR VENTS
CHILLED & HEATING HOT WATER

NOT TO SCALE
ELEVATION

CONCRETE STRUCTURE
3/4" DIAMETER ANCHOR BOLTS (TYP.)
PIPE GUIDE
ALIGNMENT COLLAR
3/8" FILLET WELD (TYPICAL)
3/4" BASE PLATE

PIPING (ABOVE)

BASE PLATE (PLAN VIEW)

2" 8" 2"
12"
2" 2"

VARIES. COORDINATE WITH PIPE DIAMETER TO ALLOW ANCHOR BOLT HOLES TO BE DRILLED CORRECTLY AFTER ANCHOR IS WELDED TO PIPING.

PIPE GUIDE DETAIL
NOT TO SCALE
8" CONC. BLOCK WALL
3/4" DIAMETER ANCHOR BOLTS (TYP.)
PIPE GUIDE
ALIGNMENT COLLAR

3/8" FILLET WELD (TYPICAL)
3/4" BASE PLATE

PIPING (ABOVE)

VARIES. COORDINATE WITH PIPE DIAMETER TO ALLOW ANCHOR BOLT HOLES TO BE DRILLED CORRECTLY AFTER ANCHOR IS WELDED TO PIPING.

ELEVATION

BASE PLATE (PLAN VIEW)

NOT TO SCALE
PIPE ANCHOR DETAIL

ELEVATION

BASE PLATE (PLAN VIEW)

CONCRETE STRUCTURE
3/4" BASE PLATE
3/4" DIAMETER ANCHOR BOLTS (TYP.)
STEEL PIPE

PIPING (ABOVE)
3/8" FILLET WELD (TYPICAL)
3/4" BASE PLATE
3/8" FILLET WELD (TYPICAL)

MATCH GUIDE DIMENSION

2" 8" 2"
2" 12" 2"

VARIES. COORDINATE WITH PIPE DIAMETER TO ALLOW ANCHOR BOLT HOLES TO BE DRILLED CORRECTLY AFTER ANCHOR IS WELDED TO PIPING.

NOT TO SCALE
ELEVATION

3/4" BASE PLATE
8" CONC. BLOCK WALL
3/4" BASE PLATE
3/4" DIAMETER ANCHOR BOLTS (TYP.)

STEEL PIPE

MATCH GUIDE DIMENSION

BASE PLATE (PLAN VIEW)

2" 8" 2" 2"

3/8" FILLET WELD (TYPICAL)
3/4" BASE PLATE
3/8" FILLET WELD (TYPICAL)

VARIIES. COORDINATE WITH PIPE DIAMETER TO ALLOW ANCHOR BOLT HOLES TO BE DRILLED CORRECTLY AFTER ANCHOR IS WELDED TO PIPING.
SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Testing, adjustment, and balancing of air systems.

B. Testing, adjustment, and balancing of hydronic, steam, and refrigerating systems.

C. Measurement of final operating condition of HVAC systems.

D. Sound measurement of equipment operating conditions.

E. Vibration measurement of equipment operating conditions.

F. Commissioning activities.

1.02 RELATED SECTIONS

A. Section 01 91 00 – General Commissioning Requirements: Commissioning requirements that apply to all types of work.

B. Section 23 08 00 - Commissioning of HVAC.

1.03 REFERENCES


1.04 SUBMITTALS

A. See Administrative Requirements, for submittal procedures.

B. Qualifications: Submit name of adjusting and balancing agency and TAB supervisor for approval within 30 days after award of Contract.

C. TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing approach for each system and component.

1. Submit to Architect.

2. Submit to the Commissioning Authority.

3. Submit six weeks prior to starting the testing, adjusting, and balancing work.

4. Include certification that the plan developer has reviewed the contract documents, the equipment and systems, and the control system with the Architect and other installers to sufficiently understand the design intent for each system.
5. Include at least the following in the plan:
   a. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
   b. Copy of field checkout sheets and logs to be used, listing each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
   c. Identification and types of measurement instruments to be used and their most recent calibration date.
   d. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
   e. Final test report forms to be used.
   f. Detailed step-by-step procedures for TAB work for each system and issue, including:
      1) Terminal flow calibration (for each terminal type).
      2) Diffuser proportioning.
      3) Branch/submain proportioning.
      4) Total flow calculations.
      5) Rechecking.
      6) Diversity issues.
   g. Details of how TOTAL flow will be determined; for example:
      1) Air: Sum of terminal flows via control system calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pitot traverse, SA or RA flow stations.
      2) Water: Pump curves, circuit setter, flow station, ultrasonic, etc.
   h. Confirmation of understanding of the outside air ventilation criteria under all conditions.
   i. Method of verifying and setting minimum outside air flow rate will be verified and set and for what level (total building, zone, etc.).
   j. Method of checking building static and exhaust fan and/or relief damper capacity.
   k. Proposed selection points for sound measurements and sound measurement methods.
   l. Methods for making coil or other system plant capacity measurements, if specified.
   m. Time schedule for TAB work to be done in phases (by floor, etc.).
   n. Description of TAB work for areas to be built out later, if any.
   o. Time schedule for deferred or seasonal TAB work, if specified.
p. False loading of systems to complete TAB work, if specified.
q. Exhaust fan balancing and capacity verifications, including any required room pressure differentials.
r. Procedures for field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).
s. Procedures for formal progress reports, including scope and frequency.
t. Procedures for formal deficiency reports, including scope, frequency and distribution.

D. Field Logs: Submit at least twice a week to Commissioning Authority.

E. Control System Coordination Reports: Communicate in writing to the controls installer all setpoint and parameter changes made or problems and discrepancies identified during TAB which affect the control system setup and operation.

F. Progress Reports.

G. Final Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
   1. Submit to the Commissioning Authority within two weeks after completion of testing, adjusting, and balancing.
   2. Revise TAB plan to reflect actual procedures and submit as part of final report.
   3. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Architect and for inclusion in operating and maintenance manuals.
   4. Provide reports in soft cover, letter size, 3-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.
   5. Include actual instrument list, with manufacturer name, serial number, and date of calibration.
   6. Test Reports: Indicate data on AABC MN-1 forms, forms prepared following ASHRAE Std 111, or NEBB forms.
   7. Include the following on the title page of each report:
      a. Name of Testing, Adjusting, and Balancing Agency.
      b. Address of Testing, Adjusting, and Balancing Agency.
      c. Telephone number of Testing, Adjusting, and Balancing Agency.
      d. Project name.
e. Project location.
f. Project Architect.
g. Project Engineer.
h. Project Contractor.
i. Project altitude.
j. Report date.

H. Project Record Documents: Record actual locations of flow measuring stations and balancing valves and rough setting.

1.05 QUALITY ASSURANCE

A. Perform total system balance in accordance with ASHRAE Std 111 or NEBB Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems.
   1. Maintain one copy of each document on site.

B. TAB Agency Qualifications: Company specializing in the testing, adjusting, and balancing of systems specified in this Section with minimum three years documented experience.

C. Perform Work under supervision of NEBB Certified Testing, Balancing and Adjusting Supervisor experienced in performance of this Work and licensed at the State in which the Project is located.

1.06 PRE-BALANCING MEETING

A. Convene a meeting one week prior to commencing work of this Section.

1.07 SEQUENCING AND SCHEDULING

A. Sequence work to commence after completion of systems and schedule completion of work before Substantial Completion of Project.

B. Schedule and provide assistance in final adjustment and test of life safety system with Fire Authority.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
   1. Systems are started and operating in a safe and normal condition.
   2. Temperature control systems are installed complete and operable.
   3. Proper thermal overload protection is in place for electrical equipment.
4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
5. Duct systems are clean of debris.
6. Fans are rotating correctly.
7. Fire and volume dampers are in place and open.
8. Air coil fins are cleaned and combed.
9. Access doors are closed and duct end caps are in place.
10. Air outlets are installed and connected.
11. Duct system leakage is minimized.
12. Hydronic systems are flushed, filled, and vented.
13. Pumps are rotating correctly.
14. Proper strainer baskets are clean and in place.
15. Service and balance valves are open.

B. Submit field reports. Report defects and deficiencies noted during performance of services which prevent system balance.

C. Beginning of work means acceptance of existing conditions.

3.02 PREPARATION

A. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Engineer to facilitate spot checks during testing.

B. Provide additional balancing devices as required.

3.03 INSTALLATION TOLERANCES

A. Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.

B. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.

C. Hydronic Systems: Adjust to within plus or minus 10 percent of design.

3.04 RECORDING AND ADJUSTING

A. Field Logs: Maintain written logs including:
   1. Running log of events and issues.
   2. Discrepancies, deficient or uncompleted work by others.
   4. Lists of completed tests.

B. Ensure recorded data represents actual measured or observed conditions.
C. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.

D. Mark on the drawings the locations where traverse and other critical measurements were taken and cross reference the location in the final report.

E. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

F. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

G. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.

3.05 FUNDAMENTAL AIR SYSTEMS' BALANCING PROCEDURES

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 traverse locations.

E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

F. Verify that motor starters are equipped with properly sized thermal protection.

G. Check dampers for proper position to achieve desired airflow path.

H. Check for airflow blockages.

I. Check condensate drains for proper connections and functioning. Check the installation per Construction Documents.

J. Check for proper sealing of air handling unit components. Report any noted discrepancies.

3.06 CONSTANT-VOLUME AIR SYSTEMS' BALANCING PROCEDURES

A. The procedures in this Article apply to constant-volume supply-, return-, and exhaust-air systems. Additional procedures are required for variable-air-volume supply-air systems and process exhaust-air systems. These additional procedures are specified in other articles in this Section.

B. Adjust fans to deliver total design airflows within the maximum allowable rpm listed by the fan manufacturer.

1. Measure fan static pressures to determine actual static pressure as follows:
a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from take-offs and restrictions in ducts such as elbows and transitions.

b. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.

c. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

2. Measure static pressure across each air handling unit component.

3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers under final balanced conditions.

4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.

5. Adjust fan speed higher or lower than design with the approval of the Contracting Officer. Make recommendations for required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes. Changes to be the responsibility of the installing contractor.

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 no overload will occur. Measure and record amperage in full cooling, full heating, and economizer modes to determine the maximum required brake horsepower.

C. Adjust volume dampers for main duct, submain ducts, and major branch ducts to design airflows within specified tolerances.

D. Measure terminal outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or the outlet manufacturer's written instructions and calculating factors.

E. Adjust terminal outlets and inlets for each space to design airflows within specified tolerances of design values. Make adjustments using volume dampers rather than extractors and the dampers at the air terminals.

1. Adjust each outlet in the same room or space to within specified tolerances of design quantities without generating noise levels above the limitations prescribed by the Contract Documents.

2. Adjust patterns of adjustable outlets for proper distribution without drafts.
3.07 VARIABLE-AIR-VOLUME SYSTEMS’ ADDITIONAL PROCEDURES

A. Compensating for Diversity: When the total airflow of all terminal units is more than the fan design airflow volume, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the design airflow of the fan. Select these 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 outside-air dampers at minimum, and return-air 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 duct losses.

3. Measure total system airflow. Adjust to within 10 percent of design airflow.

4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use the terminal unit manufacturers written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units 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 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.

6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets 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 adequate static pressure is maintained at the most critical unit.

8. Record the final fan performance data.
3.08 VARIABLE VOLUME TERMINAL UNIT TEST PROCEDURES INCLUDING SUPPLY AND EXHAUST OFFICE AND LABORATORY APPLICATIONS

A. The TAB Contractor shall verify installed equipment matches data indicated in the Construction Documents and Submittal Data including but not limited to; terminal unit inlet and outlet size, designation, and type. If the control system is DDC, verify correctly programmed duct size, cooling flow maximum and minimum airflows, heating flow maximum and minimum airflows and application type. Verify that all terminal unit averaging velocity sensor pressure ports are manifolde together so as to have an average DP reading at the terminal unit airflow calculating station.

B. The TAB Contractor (with the assistance of the Automatic Temperature Control Contractor) shall verify that the differential pressure transmitter has been properly calibrated (zero and span adjustments). The TAB Contractor (with the assistance of the Automatic Temperature Control Contractor) shall then disconnect the pneumatic tubes at the averaging velocity sensor and adjust the zero setting such that the transmitter reads zero (0) CFM. After verification, the TAB Contractor shall reconnect the pneumatic tubes.

C. The TAB Contractor shall connect a differential pressure gauge to the capped tees in the pneumatic tubes (to be installed by the Automatic Temperature Control Contractor) and measure the differential pressure. The TAB Contractor shall convert the measured differential pressure to air flow using the charts provided by the air terminal supplier. The TAB Contractor shall record the measured differential pressure and the calculated airflow. The TAB Contractor shall then remove the differential pressure gauge and reinstall the tube caps.

D. Recorded Test Data shall include but not be limited to; terminal unit designation, type, size, room number served for each connected grille/register/diffuser, design and actual cooling flow minimum and maximum airflows, design and actual heating flow minimum and maximum airflows, DDC correction/calibration factors, (correction/calibration coefficients that deviate significantly from the normal setting, as determined by the terminal unit manufacturer, should be scrutinized very closely to ensure that the deviation is not due to an air leak, improper control setting, etc.), first and final diffuser readings, balometer verses computer readings each at 25%, 50% and 100% of design cooling flow (to verify accuracy across the control range), and the measured differential pressure and the calculated airflow (Reference "C" above).

E. The TAB Contractor shall derive the correction/calibration factors using the manufacturers published recommendations and methods. Unless stated otherwise in the Construction Documents, correction/calibrations factors shall be set with the air volume at the maximum cooling CFM and tolerances verified at 50% and 25%.
3.09 CONSTANT VOLUME TERMINAL UNIT TEST PROCEDURES

A. The TAB Contractor shall verify installed equipment matches data indicated in the Construction Documents and Submittal Data including but not limited to; terminal unit inlet and outlet size, designation, and type. If the control system is DDC, verify correctly programmed duct size, cooling flow maximum and minimum airflows, heating flow maximum and minimum airflows and application type. Verify that all terminal unit averaging velocity sensor pressure ports are manifolded together so as to have an average DP reading at the terminal unit airflow calculating station.

B. The TAB Contractor (with the assistance of the Automatic Temperature Control Contractor) shall verify that the differential pressure transmitter has been properly calibrated (zero and span adjustments). The TAB Contractor (with the assistance of the Automatic Temperature Control Contractor) shall then disconnect the pneumatic tubes at the averaging velocity sensor and adjust the zero setting such that the transmitter reads zero (0) CFM. After verification, the TAB Contractor shall reconnect the pneumatic tubes.

C. The TAB Contractor shall connect a differential pressure gauge to the capped tees in the pneumatic tubes (to be installed by the Automatic Temperature Control Contractor) and measure the differential pressure. The TAB Contractor shall convert the measured differential pressure to air flow using the charts provided by the air terminal supplier. The TAB Contractor shall record the measured differential pressure and the calculated airflow. The TAB Contractor shall then remove the differential pressure gauge and reinstall the tube caps.

D. Recorded Test Data shall include but not be limited to; terminal unit designation, type, size, room number served for each connected grille/register/diffuser, design and actual cooling and heating airflow, DDC correction/calibration factors (correction/calibration coefficients that deviate significantly from the normal setting, as determined by the terminal unit manufacturer, should be scrutinized very closely to ensure that the deviation is not due to an air leak, improper control setting, etc.), first and final diffuser readings, and the measured differential pressure and the calculated airflow (Reference "C" above).

E. Correction/calibration factors shall be derived using manufacturers published recommendations and methods. Unless stated otherwise in the Construction Documents, correction/calibrations factors shall be set with the air volume at the cooling CFM.

3.10 LABORATORY FUME HOOD

A. The TAB Contractor shall verify that the fume hood face velocity is within acceptable parameters for at least but not limited to, three (3) different sash heights including 9", 18", and full open; by application of a hot-wire-anemometer average velocity traverse, Vel-grid average velocity traverse, or other accepted methods as indicated by the Engineer of Record. Record traverse velocities and include in final documentation.
3.11 LAB ROOM PRESSURE RELATIONSHIP VERIFICATION

A. Verify in occupied Maximum and Minimum airflow settings and un-occupied Maximum and Minimum airflow setting with the sash height at closed, 9", 18", and at full open, that the room maintains design pressure relationship to adjacent areas.

3.12 DUCT MOUNTED AIRFLOW MEASURING STATIONS

A. Duct mounted airflow measuring station: Verify installation complies with Construction Documents and manufacturers published recommendations. Verify the accuracy of the reported airflow from each airflow measuring station either through a comparison by direct traverse or by comparison of known airflows. Example: Determine the actual airflow where the airflow-measuring device is installed by traverse if sufficient duct length exists, or traverse the unit discharge airflow minus unit return airflow equals outside airflow. Indicate the method used and the reported accuracy of the airflow-measuring station volume in the comment section of the Fan Test Report document.

B. The TAB Contractor (with the assistance of the Automatic Temperature Control Contractor) shall verify that the differential pressure transmitter has been properly calibrated (zero and span adjustments). The TAB Contractor (with the assistance of the Automatic Temperature Control Contractor) shall adjust the averaging velocity sensor to zero the setting, such that the transmitter reads zero (0) CFM.

C. Recorded Test Data shall include but not be limited to; airflow measuring station designation, type, size, air handler served, design and actual airflow, DDC correction/calibration factors (correction/calibration coefficients that deviate significantly from the normal setting, as determined by the terminal unit manufacturer, should be scrutinized very closely to ensure that the deviation is not due to an air leak, improper control setting, etc.), first and final readings, and the measured differential pressure across the airflow measuring station.

3.13 FAN INLET MOUNTED AIRFLOW MEASURING STATIONS

A. Fan inlet mounted airflow measuring station: Verify installation complies with Construction Documents and manufacturers published recommendations. Verify the accuracy of the reported airflow from each airflow measuring station by direct comparison to a traverse of the unit discharge airflow. Indicate the reported accuracy of the airflow measuring station volume in the comment section of the Fan Test Report document.
B. The TAB Contractor (with the assistance of the Automatic Temperature Control Contractor) shall verify that the differential pressure transmitter has been properly calibrated (zero and span adjustments). The TAB Contractor (with the assistance of the Automatic Temperature Control Contractor) shall adjust the averaging velocity sensor to zero the setting, such that the transmitter reads zero (0) CFM.

3.14 RECORDED TEST DATA: shall include but not be limited to; airflow measuring station designation, type, size, air handler served, design and actual airflow, DDC correction/calibration factors (correction/calibration coefficients that deviate significantly from the normal setting, as determined by the terminal unit manufacturer, should be scrutinized very closely to ensure that the deviation is not due to an air leak, improper control setting, etc.), and first and final readings.

3.15 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 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 expansion tank liquid level.
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 design 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.
3.16 HYDRONIC SYSTEMS’ BALANCING PROCEDURES

A. Determine 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. Verify with the pump manufacturer that this will not damage pump. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on the manufacturer's pump curve at zero flow and confirm that the pump has the intended impeller size.

2. Check system resistance. With all valves open, read pressure differential across the pump and mark the pump manufacturer's head-capacity curve. Adjust pump discharge valve until design water flow is achieved.

3. If pump motor is equipped with a variable frequency drive, note and record the motor frequency at which design flow is achieved. Do not adjust or close the pump discharge valve to reach design flow unless the pump motor amperage is exceeding the nameplate amps time the service factor.

4. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on the pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.

5. Report flow rates that are not within plus or minus 5 percent of design.

B. Set calibrated balancing valves, if installed, at calculated pre-settings.

C. 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.

D. Measure flow at main balancing station and set main balancing device to achieve design flow + 5%.

E. Adjust balancing stations to within specified tolerances of design flow rate as follows:

1. Determine the balancing station with the highest percentage over design flow.

2. Adjust each station in turn, beginning with the station with the highest percentage over design flow and proceeding to the station with the lowest percentage over design flow.

3. Record settings and mark balancing devices.
F. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems’ pressures and temperatures, including outdoor-air temperature.

G. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

H. Record final pressures and flows on the appropriate forms.

3.17 VARIABLE-FLOW HYDRONIC SYSTEMS' ADDITIONAL PROCEDURES

A. Balance systems with automatic 2-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.18 HEAT EXCHANGERS

A. Measure water flow through all circuits.

B. Adjust water flow to within specified tolerances.

C. Measure inlet and outlet water temperatures.

D. Measure and record the inlet steam pressure. Check the setting and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves.

E. Record safety valve settings.

F. The TAB Contractor (with the assistance of the Mechanical Contractor) shall verify operation of steam traps.

3.19 MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
   1. Manufacturer, model, and serial numbers.
   4. Efficiency rating if high-efficiency motor.
   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 for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.
3.20 CHILLERS

A. Balance water flow through each evaporator and condenser to within specified tolerances of design flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:

1. Evaporator water entering and leaving temperatures, pressure drop, and water flow.
2. Condenser water entering and leaving temperatures, pressure drop, and water flow.
3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by the chiller manufacturer.
4. Power factor if factory-installed instrumentation is furnished for measuring kW.
5. The kW input if factory-installed instrumentation is furnished for measuring kW.

3.21 COOLING TOWERS

A. Shut off makeup water for the duration of the test, and then make sure the makeup and blow-down systems are fully operational after tests and before leaving the equipment. Perform the following tests and record the results:

1. If capabilities exist, measure condenser water flow to each cell of the cooling tower.
2. Measure entering- and leaving-water temperatures.
3. Measure wet- and dry-bulb temperatures of air entering the tower.
4. Measure wet- and dry-bulb temperatures of air leaving the tower.
5. If applicable, measure condenser water flow rate recirculating through the cooling tower.
6. Measure cooling tower pump discharge pressure.
7. The TAB Contractor (with the assistance of the Mechanical Contractor) shall verify correct adjustment of water level and feed rate of makeup-water system.

3.22 HEAT-TRANSFER COILS

A. Water Coils: Measure the following data for each coil:

1. Entering- and leaving-water temperatures.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperatures of entering and leaving air.
5. Wet-bulb temperatures of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

3.23 TEMPERATURE TESTING
A. During testing, adjusting, and balancing, report need for adjustment in temperature regulation within the automatic temperature-control system.
B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of 2 successive 8-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.
C. At the same time as the above reading are taken, measure outside-air, wet- and dry-bulb temperatures.

3.24 TEMPERATURE-CONTROL VERIFICATION
A. Verify that controllers are calibrated and commissioned. Include Control Contractor Commissioning reports in final submittal.
B. Check transmitter and controller locations and note conditions that would adversely affect control functions.
C. Record controller settings and note variances between set points and actual measurements.
D. Verify operation of limiting controllers (i.e., high- and low-temperature controllers).
E. Verify free travel and proper operation of control devices such as damper and valve operators.
F. Verify sequence of operation of control devices. Note and record on the proper forms, air pressures and device positions and correlate with airflow and water-flow measurements. Note and record on the proper forms, the speed of response to input changes.
G. The TAB Contractor (with the assistance of the Automatic Temperature Control Contractor) shall confirm interaction of electrically operated switch transducers.
H. Confirm interaction of interlock and lockout systems.
I. The TAB Contractor (with the assistance of the Automatic Temperature Control Contractor) shall verify main control supply-air pressure and observe compressor and dryer operations. If issues are noted with the control supply-air pressure, compressor, or dryer operations, document and relay this information to the General Contractor.
J. Record voltages of power supply and controller output. Determine and document if the system operates on a grounded or non-grounded power supply.
K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.25 COMMISSIONING

A. See Sections 17030 and 17031 for additional requirements.

B. Fill out Prefunctional Checklists for:
   1. Air side systems.
   2. Water side systems.

C. Furnish to the Commissioning Authority, upon request, any data gathered but not shown in the final TAB report.

D. Re-check minimum outdoor air intake flows and maximum and intermediate total airflow rates for the air handlers as directed by Commission Authority.
   1. Original TAB agency shall execute the re-checks, witnessed by the Commissioning Authority.
   2. Use the same test instruments as used in the original TAB work.
   3. Failure of more than 10 percent of the re-checked items of a given system shall result in the rejection of the system TAB report; rebalance the system, provide a new system TAB report, and repeat random re-checks.
   4. For purposes of re-check, failure is defined as follows:
      a. Air Flow of Supply and Return: Deviation of more than 10 percent of instrument reading.
      b. Minimum Outside Air Flow: Deviation of more than 20 percent of instrument reading; for inlet vane or VFD OSA compensation system using linear proportional control, deviation of more than 30 percent at intermediate supply flow.
      c. Temperatures: Deviation of more than one degree F.
      d. Air and Water Pressures: Deviation of more than 10 percent of full scale of test instrument reading.
      e. Sound Pressures: Deviation of more than 3 decibels, with consideration for variations in background noise.
   5. For purposes of re-check, a whole system is defined as one in which inaccuracies will have little or no impact on connected systems; for example, the air distribution system served by one air handler or the hydronic chilled water supply system served by a chiller or the condenser water system.

E. In the presence of the Commissioning Authority, verify that:
   1. Final settings of all valves, splitters, dampers and other adjustment devices have been permanently marked.
2. The air system is being controlled to the lowest possible static pressure while still meeting design loads, less diversity; this shall include a review of TAB methods, established control setpoints, and physical verification of at least one leg from fan to diffuser having all balancing dampers wide open and that during full cooling of all terminal units taking off downstream of the static pressure sensor, the terminal unit on the critical leg has its damper 90 percent or more open.

3. The water system is being controlled to the lowest possible pressure while still meeting design loads, less diversity; this shall include a review of TAB methods, established control setpoints, and physical verification of at least one leg from the pump to the coil having all balancing valves wide open and that during full cooling the cooling coil valve of that leg is 90 percent or more open.

3.26 SCOPE

A. Test, adjust, and balance the following:

1. Steam Condensate Pumps
2. Boiler Feedwater Pumps
3. HVAC Pumps
4. Water Tube Boilers
5. Packaged Steel Water Tube Boilers
6. Packaged Steel Fire Tube Boilers
7. Forced Air Furnaces
8. Direct Fired Furnaces
9. Reciprocating Water Chillers
10. Air Cooled Water Chillers
11. Centrifugal Water Chillers
12. Absorption Water Chillers
13. Induced Draft Cooling Tower
14. Blow Through Cooling Tower
15. Air Cooled Refrigerant Condensers
16. Packaged Roof Top Heating/Cooling Units
17. Packaged Terminal Air Conditioning Units
18. Unit Air Conditioners
19. Computer Room Air Conditioning Units
20. Air Coils
21. Evaporative Humidifier
22. Sprayed Coil Dehumidifier
23. Terminal Heat Transfer Units  
24. Induction Units  
25. Air Handling Units  
26. Fans  
27. Air Filters  
28. Air Terminal Units  
29. Air Inlets and Outlets  
30. Controls Compressor  
31. Laboratory Fume Hoods

3.27 MINIMUM DATA TO BE REPORTED

A. Electric Motors:
   1. Manufacturer  
   2. Model/frame  
   3. HP/BHP  
   4. Phase, voltage, amperage; nameplate, actual, no load  
   5. RPM  
   6. Service factor  
   7. Starter size, rating, heater elements  
   8. Sheave make/size/bore

B. V-Belt Drives:
   1. Identification/location  
   2. Required driven RPM  
   3. Driven sheave, diameter and RPM  
   4. Belt, size and quantity  
   5. Motor sheave diameter and RPM  
   6. Center to center distance, maximum, minimum, and actual

C. Pumps:
   1. Identification/number  
   2. Manufacturer  
   3. Size/model  
   4. Impeller  
   5. Service  
   6. Design flow rate, pressure drop, BHP
7. Actual flow rate, pressure drop, BHP
8. Discharge pressure
9. Suction pressure
10. Total operating head pressure
11. Shut off, discharge and suction pressures
12. Shut off, total head pressure

D. Air Cooled Condensers:
1. Identification/number
2. Location
3. Manufacturer
4. Model number
5. Serial number
6. Entering DB air temperature, design and actual
7. Leaving DB air temperature, design and actual
8. Number of compressors

E. Chillers:
1. Identification/number
2. Manufacturer
3. Capacity
4. Model number
5. Serial number
6. Evaporator entering water temperature, design and actual
7. Evaporator leaving water temperature, design and actual
8. Evaporator pressure drop, design and actual
9. Evaporator water flow rate, design and actual
10. Condenser entering water temperature, design and actual
11. Condenser pressure drop, design and actual
12. Condenser water flow rate, design and actual

F. Cooling Tower:
1. Tower identification/number
2. Manufacturer
3. Model number
4. Serial number
5. Rated capacity
6. Entering air WB temperature, specified and actual
7. Leaving air WB temperature, specified and actual
8. Ambient air DB temperature
9. Condenser water entering temperature
10. Condenser water leaving temperature
11. Condenser water flow rate
12. Fan RPM

G. Heat Exchangers:
   1. Identification/number
   2. Location
   3. Service
   4. Manufacturer
   5. Model number
   6. Serial number
   7. Steam pressure, design and actual
   8. Primary water entering temperature, design and actual
   9. Primary water leaving temperature, design and actual
  10. Primary water flow, design and actual
  11. Primary water pressure drop, design and actual
  12. Secondary water leaving temperature, design and actual
  13. Secondary water leaving temperature, design and actual
  14. Secondary water flow, design and actual
  15. Secondary water pressure drop, design and actual

H. Cooling Coils:
   1. Identification/number
   2. Location
   3. Service
   4. Manufacturer
   5. Air flow, design and actual
   6. Entering air DB temperature, design and actual
   7. Entering air WB temperature, design and actual
   8. Leaving air DB temperature, design and actual
9. Leaving air WB temperature, design and actual
10. Water flow, design and actual
11. Water pressure drop, design and actual
12. Entering water temperature, design and actual
13. Leaving water temperature, design and actual
14. Saturated suction temperature, design and actual
15. Air pressure drop, design and actual

I. Heating Coils:
   1. Identification/number
   2. Location
   3. Service
   4. Manufacturer
   5. Air flow, design and actual
   6. Water flow, design and actual
   7. Water pressure drop, design and actual
   8. Entering water temperature, design and actual
   9. Leaving water temperature, design and actual
  10. Entering air temperature, design and actual
  11. Leaving air temperature, design and actual
  12. Air pressure drop, design and actual

J. Electric Duct Heaters:
   1. Manufacturer
   2. Identification/number
   3. Location
   4. Model number
   5. Design kW
   6. Number of stages
   7. Phase, voltage, amperage
   8. Test voltage (each phase)
   9. Test amperage (each phase)
  10. Air flow, specified and actual
  11. Temperature rise, specified and actual
K. Induction Units:
1. Manufacturer
2. Identification/number
3. Location
4. Model number
5. Size
6. Design air flow
7. Design nozzle pressure drop
8. Final nozzle pressure drop
9. Final air flow

L. Air Moving Equipment:
1. Location
2. Manufacturer
3. Model number
4. Serial number
5. Arrangement/class/discharge
6. Air flow, specified and actual
7. Return air flow, specified and actual
8. Outside air flow, specified and actual
9. Total static pressure (total external), specified and actual
10. Inlet pressure
11. Discharge pressure
12. Sheave make/size/bore
13. Number of belts/make/size
14. Fan RPM

M. Return Air/Outside Air:
1. Identification/location
2. Design air flow
3. Actual air flow
4. Design return air flow
5. Actual return air flow
6. Design outside air flow
7. Actual outside air flow
8. Return air temperature
9. Outside air temperature
10. Required mixed air temperature
11. Actual mixed air temperature
12. Design outside/return air ratio
13. Actual outside/return air ratio

N. Exhaust Fans:
1. Location
2. Manufacturer
3. Model number
4. Serial number
5. Air flow, specified and actual
6. Total static pressure (total external), specified and actual
7. Inlet pressure
8. Discharge pressure
9. Sheave make/size/bore
10. Number of belts/make/size
11. Fan RPM

O. Duct Traverses:
1. System zone/branch
2. Duct size
3. Area
4. Design velocity
5. Design air flow
6. Test velocity
7. Test air flow
8. Duct static pressure
9. Air temperature
10. Air correction factor

P. Air Monitoring Stations:
1. Identification/location
2. System
3. Size
4. Area
5. Design velocity
6. Design air flow
7. Test velocity
8. Test air flow

Q. Flow Measuring Stations:
1. Identification/number
2. Location
3. Size
4. Manufacturer
5. Model number
6. Serial number
7. Design flow rate
8. Design pressure drop
9. Actual/final pressure drop
10. Actual/final flow rate
11. Station calibrated setting

R. Terminal Unit Data:
1. Manufacturer
2. Type, constant, variable, single, dual duct
3. Identification/number
4. Location
5. Model number
6. Size
7. Minimum static pressure
8. Minimum design air flow
9. Maximum design air flow
10. Maximum actual air flow
11. Inlet static pressure

S. Air Distribution Tests:
1. Air terminal number
2. Room number/location
3. Terminal type
4. Terminal size
5. Design air flow

T. Vibration Tests:
1. Location of points:
   a. Fan bearing, drive end
   b. Fan bearing, opposite end
   c. Motor bearing, center (if applicable)
   d. Motor bearing, drive end
   e. Motor bearing, opposite end
   f. Casing (bottom or top)
   g. Casing (side)
   h. Duct after flexible connection (discharge)
   i. Duct after flexible connection (suction)
2. Test readings:
   a. Horizontal, velocity and displacement
   b. Vertical, velocity and displacement
   c. Axial, velocity and displacement
3. Normally acceptable readings, velocity and acceleration
4. Unusual conditions at time of test
5. Vibration source (if non-complying)

END OF SECTION
SECTION 17030 - COMMISSIONING

PART 1  GENERAL

1.01  SUMMARY

A. Commissioning is intended to achieve the following specific objectives; this section specifies the Contractor's responsibilities for commissioning:

1. Verify that the work is installed in accordance with the Contract Documents and the manufacturer's recommendations and instructions, and that it receives adequate operational checkout prior to startup: Startup reports and Prefunctional Checklists executed by Contractor are utilized to achieve this.

2. Verify and document that functional performance is in accordance with the Contract Documents: Functional Tests executed by Contractor and witnessed by the Commissioning Authority are utilized to achieve this.

3. Verify that operation and maintenance manuals submitted to Owner are complete: Detailed operation and maintenance (O&M) data submittals by Contractor are utilized to achieve this.

4. Verify that the Owner's operating personnel are adequately trained: Formal training conducted by Contractor is utilized to achieve this.

B. Commissioning, including Functional Tests, O&M documentation review, and training, is to occur after startup and initial checkout and be completed before Substantial Completion.

C. The Commissioning Authority directs and coordinates all commissioning activities; this section describes some but not all of the Commissioning Authority's responsibilities.

D. The Commissioning Authority is employed by Owner.

1.02  SCOPE OF COMMISSIONING

A. The following are to be commissioned:

B. Plumbing Systems:

1. Water heaters.
2. Booster pumps.

C. HVAC System, including:

1. Major and minor equipment items.
2. Piping systems and equipment.
3. Ductwork and accessories.
4. Terminal units.
5. Control system.
8. Variable frequency drives.

D. Special Ventilation:
1. Fume hoods.
2. Laboratory pressurization.
4. Egress pressurization.

E. Electrical Systems:
1. Power quality.
2. Emergency power systems.
3. Uninterruptible power systems.
4. Lighting controls other than manual switches.

F. Electronic Safety and Security:
1. Fire and smoke alarms.

G. Other equipment and systems explicitly identified elsewhere in Contract Documents as requiring commissioning.

1.03 RELATED SECTIONS
A. Section 01780 - Closeout Submittals: Scope and procedures for operation and maintenance manuals and project record documents.
B. Section 17031 - Commissioning of HVAC: HVAC control system testing; other requirements.

1.04 SUBMITTALS
A. See Section 01300 - Administrative Requirements, for submittal procedures; except:
1. Make all submittals specified in this section, and elsewhere where indicated for commissioning purposes, directly to the Commissioning Authority, unless they require review by Architect; in that case, submit to Architect first.
2. Submit one copy to the Commissioning Authority, not to be returned.
3. Make commissioning submittals on time schedule specified by Commissioning Authority.
4. Submittals indicated as "Draft" are intended for the use of the Commissioning Authority in preparation of Prefunctional Checklists or Functional Test requirements; submit in editable electronic format, Microsoft Word 2003 preferred.
5. As soon as possible after submittals made to Architect are approved, submit copy of approved submittal to the Commissioning Authority.
B. Manufacturers' Instructions: Submit copies of all manufacturer-provided instructions that are shipped with the equipment as soon as the equipment is delivered.

C. Product Data: If submittals to Architect do not include the following, submit copies as soon as possible:
   1. Manufacturer's product data, cut sheets, and shop drawings.
   2. Manufacturer's installation instructions.
   3. Startup, operating, and troubleshooting procedures.
   4. Fan and pump curves.
   5. Factory test reports.
   6. Warranty information, including details of Owner's responsibilities in regard to keeping warranties in force.

D. Startup Plans and Reports.

E. Completed Prefunctional Checklists.

PART 2 PRODUCTS

2.01 TEST EQUIPMENT

A. Provide all standard testing equipment required to perform startup and initial checkout and required Functional Testing; unless otherwise noted such testing equipment will NOT become the property of Owner.

B. Calibration Tolerances: Provide testing equipment of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified. If not otherwise noted, the following minimum requirements apply:
   1. Temperature Sensors and Digital Thermometers: Certified calibration within past year to accuracy of 0.5 degree F and resolution of plus/minus 0.1 degree F.
   2. Pressure Sensors: Accuracy of plus/minus 2.0 percent of the value range being measured (not full range of meter), calibrated within the last year.
   3. Calibration: According to the manufacturer's recommended intervals and when dropped or damaged; affix calibration tags or keep certificates readily available for inspection.

C. Equipment-Specific Tools: Where special testing equipment, tools and instruments are specific to a piece of equipment, are only available from the vendor, and are required in order to accomplish startup or Functional Testing, provide such equipment, tools, and instruments as part of the work at no extra cost to Owner; such equipment, tools, and instruments are to become the property of Owner.

D. Dataloggers: Independent equipment and software for monitoring flows, currents, status, pressures, etc. of equipment.
   1. Dataloggers required to for Functional Tests will be provided by the Commissioning Authority and will not become the property of Owner.
PART 3 EXECUTION

3.01 COMMISSIONING PLAN

A. Commissioning Authority has prepared the Commissioning Plan.
   1. Attend meetings called by the Commissioning Authority for purposes of completing the commissioning plan.
   2. Require attendance and participation of relevant subcontractors, installers, suppliers, and manufacturer representatives.

B. Contractor is responsible for compliance with the Commissioning Plan.

C. Commissioning Plan: The commissioning schedule, procedures, and coordination requirements for all parties in the commissioning process.
   1. Commissioning will be phased (by floors, for example) to minimize the total construction time.
   2. Basis of Design Documentation: Detailed documentation prepared by Architect of the functional requirements of the project; descriptions of the systems, components, and methods chosen to meet the design intent; assumptions underlying the design intent.

D. Commissioning Schedule:
   1. Submit anticipated dates of startup of each item of equipment and system to Commissioning Authority within 60 days after award of Contract.
   2. Re-submit anticipated startup dates monthly, but not less than 4 weeks prior to startup.
   3. Prefunctional Checklists and Functional Tests are to be performed in sequence from components, to subsystems, to systems.
   4. Provide sufficient notice to Commissioning Authority for delivery of relevant Checklists and Functional Test procedures, to avoid delay.

3.02 DOCUMENTATION IDENTIFICATION SYSTEM

A. Give each submitted form or report a unique identification; use the following scheme.

B. Type of Document: Use the following prefixes:
   1. Startup Plan: SP-
   2. Startup Report: SR-
   3. Prefunctional Checklist: PC-
   4. Functional Test Procedure: FTP-
   5. Functional Test Report: FTR-

C. Component Number: Assign numbers sequentially, using 1, 2, or 3 digits as required to accommodate the number of units in the system.
D. Test, Revision, or Submittal Number: Number each successive iteration sequentially, starting with 1.

3.03 STARTUP PLANS AND REPORTS

A. Startup Plans: For each item of equipment and system for which the manufacturer provides a startup plan, submit the plan not less than 8 weeks prior to startup.

B. Startup Reports: For each item of equipment and system for which the manufacturer provides a startup checklist (or startup plan or field checkout sheet), document compliance by submitting the completed startup checklist prior to startup, signed and dated by responsible entity.

C. Submit directly to the Commissioning Authority.

3.04 PREFUNCTIONAL CHECKLISTS

A. A Prefunctional Checklist is required to be filled out for each item of equipment or other assembly specified to be commissioned.

1. No sampling of identical or near-identical items is allowed.

2. These checklists do not replace manufacturers’ recommended startup checklists, regardless of apparent redundancy.

3. Prefunctional Checklist forms will not be complete until after award of the contract; the following types of information will be gathered via the completed Checklist forms:
   a. Certification by installing contractor that the unit is properly installed, started up, and operating and ready for Functional Testing.
   b. Confirmation of receipt of each shop drawing and commissioning submittal specified, itemized by unit.
   c. Manufacturer, model number, and relevant capacity information; list information "as specified," "as submitted," and "as installed."
   d. Serial number of installed unit.
   e. List of inspections to be conducted to document proper installation prior to startup and Functional Testing; these will be primarily static inspections and procedures; for equipment and systems may include normal manufacturer’s start-up checklist items and minor testing.
   f. Sensor and actuator calibration information.

4. A preliminary list of Prefunctional Checklists is attached, to indicate anticipated scope.

5. Samples of Prefunctional Checklist forms that indicate anticipated level of detail can be found at http://www.peci.org/library/mcpgs.htm.

B. Contractor is responsible for filling out Prefunctional Checklists, after completion of installation and before startup; witnessing by the Commissioning Authority is not required unless otherwise specified.
1. Each line item without deficiency is to be witnessed, initialed, and dated by the actual witness; checklists are not complete until all line items are initialed and dated complete without deficiencies.

2. Checklists with incomplete items may be submitted for approval provided the Contractor attests that incomplete items do not preclude the performance of safe and reliable Functional Testing; re-submission of the Checklist is required upon completion of remaining items.

3. Individual Checklists may contain line items that are the responsibility of more than one installer; Contractor shall assign responsibility to appropriate installers or subcontractors, with identification recorded on the form.

4. If any Checklist line item is not relevant, record reasons on the form.

5. Contractor may independently perform startup inspections and/or tests, at his option; see Section 01700 for additional general startup requirements.

6. Regardless of these reporting requirements, Contractor is responsible for correct startup and operation.

7. Submit completed Checklists to Commissioning Authority within two days of completion.

C. Commissioning Authority is responsible for furnishing the Prefunctional Checklists to Contractor.

1. Initial Drafts: Contractor is responsible for initial draft of Prefunctional Checklist where so indicated in the Contract Documents.

2. Provide all additional information requested by Commissioning Authority to aid in preparation of checklists, such as shop drawing submittals, manufacturers’ startup checklists, and O&M data.

3. Commissioning Authority may add any relevant items deemed necessary regardless of whether they are explicitly mentioned in the Contract Documents or not.

4. When asked to review the proposed Checklists, do so in a timely manner.

D. Commissioning Authority Witnessing: Required for:

1. Each piece of primary equipment, unless sampling of multiple similar units is allowed by the commissioning plan.

2. A sampling of non-primary equipment, as allowed by the commissioning plan.

E. Deficiencies: Correct deficiencies and re-inspect or re-test, as applicable, at no extra cost to Owner.

1. If difficulty in correction would delay progress, report deficiency to the Commissioning Authority immediately.
3.05 FUNCTIONAL TESTS

A. A Functional Test is required for each item of equipment, system, or other assembly specified to be commissioned, unless sampling of multiple identical or near-identical units is allowed by the final test procedures.

B. Contractor is responsible for execution of required Functional Tests, after completion of Prefunctional Checklist and before closeout.

C. Commissioning Authority is responsible for witnessing and reporting results of Functional Tests, including preparation and completion of forms for that purpose.

D. Contractor is responsible for correction of deficiencies and re-testing at no extra cost to Owner; if a deficiency is not corrected and re-tested immediately, the Commissioning Authority will document the deficiency and the Contractor's stated intentions regarding correction.

   1. Deficiencies are any condition in the installation or function of a component, piece of equipment or system that is not in compliance with the Contract Documents or does not perform properly.

   2. Use the standard form provided with copies submitted to Owner and Contractor.

   3. When the deficiency has been corrected, the Contractor completes the form certifying that the item is ready to be re-tested and returns the form to the Commissioning Authority; the Commissioning Authority will reschedule the test and the Contractor shall re-test.

   4. Identical or Near-Identical Items: If 10 percent, or three, whichever is greater, of identical or near-identical items fail to perform due to material or manufacturing defect, all items will be considered defective; provide a proposal for correction within 2 weeks after notification of defect, including provision for testing sample installations prior to replacement of all items.

   5. Contractor shall bear the cost of Owner and Commissioning Authority personnel time witnessing re-testing.

   6. Contractor shall bear the cost of Owner and Commissioning Authority personnel time witnessing re-testing if the test failed due to failure to execute the relevant Prefunctional Checklist correctly; if the test failed for reasons that would not have been identified in the Prefunctional Checklist process, Contractor shall bear the cost of the second and subsequent re-tests.

E. Functional Test Procedures:

   1. Some test procedures are included in the Contract Documents; where Functional Test procedures are not included in the Contract Documents, test procedures will be determined by the Commissioning Authority with input by and coordination with Contractor.
2. Examples of Functional Testing:
   a. Test the dynamic function and operation of equipment and systems (rather than just components) using manual (direct observation) or monitoring methods under full operation (e.g., the chiller pump is tested interactively with the chiller functions to see if the pump ramps up and down to maintain the differential pressure setpoint).
   b. Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, fire alarm, power failure, etc.
   c. Systems are run through all the HVAC control system's sequences of operation and components are verified to be responding as the sequence's state.
   d. Traditional air or water test and balancing (TAB) is not Functional Testing; spot checking of TAB by demonstration to the Commissioning Authority is Functional Testing.

F. Deferred Functional Tests: Some tests may need to be performed later, after substantial completion, due to partial occupancy, equipment, seasonal requirements, design or other site conditions; performance of these tests remains the Contractor's responsibility regardless of timing.

3.06 SENSOR AND ACTUATOR CALIBRATION

A. Calibrate all field-installed temperature, relative humidity, carbon monoxide, carbon dioxide, and pressure sensors and gages, and all actuators (dampers and valves) on this piece of equipment shall be calibrated. Sensors installed in the unit at the factory with calibration certification provided need not be field calibrated.

B. Calibrate using the methods described below; alternate methods may be used, if approved by Owner beforehand. See PART 2 for test instrument requirements. Record methods used on the relevant Prefunctional Checklist or other suitable forms, documenting initial, intermediate and final results.

C. All Sensors:
   1. Verify that sensor location is appropriate and away from potential causes of erratic operation.
   2. Verify that sensors with shielded cable are grounded only at one end.
   3. For sensor pairs that are used to determine a temperature or pressure difference, for temperature make sure they are reading within 0.2 degree F of each other, and for pressure, within tolerance equal to 2 percent of the reading, of each other.
   4. Tolerances for critical applications may be tighter.
D. Sensors Without Transmitters - Standard Application:
   1. Make a reading with a calibrated test instrument within 6 inches of the site sensor.
   2. Verify that the sensor reading, via the permanent thermostat, gage or building automation system, is within the tolerances in the table below of the instrument-measured value.
   3. If not, install offset, calibrate or replace sensor.

E. Sensors With Transmitters - Standard Application.
   1. Disconnect sensor.
   2. Connect a signal generator in place of sensor.
   3. Connect ammeter in series between transmitter and building automation system control panel.
   4. Using manufacturer’s resistance-temperature data, simulate minimum desired temperature.
   5. Adjust transmitter potentiometer zero until 4 mA is read by the ammeter.
   6. Repeat for the maximum temperature matching 20 mA to the potentiometer span or maximum and verify at the building automation system.
   7. Record all values and recalibrate controller as necessary to conform with specified control ramps, reset schedules, proportional relationship, reset relationship and P/I reaction.
   8. Reconnect sensor.
   9. Make a reading with a calibrated test instrument within 6 inches of the site sensor.
   10. Verify that the sensor reading, via the permanent thermostat, gage or building automation system, is within the tolerances in the table below of the instrument-measured value.
   11. If not, replace sensor and repeat.
   12. For pressure sensors, perform a similar process with a suitable signal generator.

F. Sensor Tolerances for Standard Applications: Plus/minus the following maximums:
   1. Watthour, Voltage, Amperage: 1 percent of design.
   2. Pressure, Air, Water, Gas: 3 percent of design.
   3. Air Temperatures (Outside Air, Space Air, Duct Air): 0.4 degrees F.
   4. Relative Humidity: 4 percent of design.
   5. Barometric Pressure: 0.1 inch of Hg.
6. Flow Rate, Air: 10 percent of design.
7. Flow Rate, Water: 4 percent of design.
8. Flow Rate, Steam: 3 percent of design.
9. AHU Wet Bulb and Dew Point: 2.0 degrees F.
10. Hot Water Coil and Boiler Water Temperature: 1.5 degrees F.
11. Cooling Coil, Chilled and Condenser Water Temperatures: 0.4 degrees F.
12. Combustion Flue Temperature: 5.0 degrees F.
13. Oxygen and CO2 Monitors: 0.1 percentage points.
14. CO Monitor: 0.01 percentage points.
15. Natural Gas and Oil Flow Rate: 1 percent of design.

G. Critical Applications: For some applications more rigorous calibration techniques may be required for selected sensors. Describe any such methods used on an attached sheet.

H. Valve/Damper Stroke Setup and Check:
1. For all valve/damper actuator positions checked, verify the actual position against the control system readout.
2. Set pump/fan to normal operating mode.
3. Command valve/damper closed; visually verify that valve/damper is closed and adjust output zero signal as required.
4. Command valve/damper to open; verify position is full open and adjust output signal as required.
5. Command valve/damper to a few intermediate positions.
6. If actual valve/damper position does not reasonably correspond, replace actuator or add pilot positioner (for pneumatics).

I. Isolation Valve or System Valve Leak Check: For valves not associated with coils.
1. With full pressure in the system, command valve closed.
2. Use an ultra-sonic flow meter to detect flow or leakage.

3.07 TEST PROCEDURES - GENERAL
A. Provide skilled technicians to execute starting of equipment and to execute the Functional Tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.

B. Provide all necessary materials and system modifications required to produce the flows, pressures, temperatures, and conditions necessary to execute the test according to the specified conditions. At completion of the test, return all affected equipment and systems to their pre-test condition.
C. Sampling: Where Functional Testing of fewer than the total number of multiple identical or near-identical items is explicitly permitted, perform sampling as follows:

1. Identical Units: Defined as units with same application and sequence of operation; only minor size or capacity difference.

2. Sampling is not allowed for:
   a. Major equipment.
   b. Life-safety-critical equipment.
   c. Prefunctional Checklist execution.

3. XX = the percent of the group of identical equipment to be included in each sample; defined for specific type of equipment.

4. YY = the percent of the sample that if failed will require another sample to be tested; defined for specific type of equipment.

5. Randomly test at least XX percent of each group of identical equipment, but not less than three units. This constitutes the "first sample."

6. If YY percent of the units in the first sample fail, test another XX percent of the remaining identical units.

7. If YY percent of the units in the second sample fail, test all remaining identical units.

8. If frequent failures occur, resulting in more troubleshooting than testing, the Commissioning Authority may stop the testing and require Contractor to perform and document a checkout of the remaining units prior to continuing testing.

D. Manual Testing: Use hand-held instruments, immediate control system readouts, or direct observation to verify performance (contrasted to analyzing monitored data taken over time to make the "observation").

E. Simulating Conditions: Artificially create the necessary condition for the purpose of testing the response of a system; for example apply hot air to a space sensor using a hair dryer to see the response in a VAV box.

F. Simulating Signals: Disconnect the sensor and use a signal generator to send an amperage, resistance or pressure to the transducer and control system to simulate the sensor value.

G. Over-Writing Values: Change the sensor value known to the control system in the control system to see the response of the system; for example, change the outside air temperature value from 50 degrees F to 75 degrees F to verify economizer operation.

H. Indirect Indicators: Remote indicators of a response or condition, such as a reading from a control system screen reporting a damper to be 100 percent closed, are considered indirect indicators.
I. Monitoring: Record parameters (flow, current, status, pressure, etc.) of equipment operation using dataloggers or the trending capabilities of the relevant control systems; where monitoring of specific points is called for in Functional Test Procedures:

1. All points that are monitored by the relevant control system shall be trended by Contractor; at the Commissioning Authority's request, Contractor shall trend up to 20 percent more points than specified at no extra charge.

2. Other points will be monitored by the Commissioning Authority using dataloggers.

3. At the option of the Commissioning Authority, some control system monitoring may be replaced with datalogger monitoring.

4. Provide hard copies of monitored data in columnar format with time down left column and at least 5 columns of point values on same page.

5. Graphical output is desirable and is required for all output if the system can produce it.

6. Monitoring may be used to augment manual testing.

3.08 OPERATION AND MAINTENANCE MANUALS

A. See Section 01780 for additional requirements.

B. Add design intent documentation furnished by Architect to manuals prior to submission to Owner.

C. Submit manuals related to items that were commissioned to Commissioning Authority for review; make changes recommended by Commissioning Authority.

D. Commissioning Authority will add commissioning records to manuals after submission to Owner.

END OF SECTION
SECTION 17031 - COMMISSIONING OF HVAC

PART 1 GENERAL

1.01 SUMMARY

A. See Section 17030 - General Commissioning Requirements for overall objectives; comply with the requirements of Section 01810.

B. This section covers the Contractor's responsibilities for commissioning; each subcontractor or installer responsible for the installation of a particular system or equipment item to be commissioned is responsible for the commissioning activities relating to that system or equipment item.

C. The Commissioning Authority (CA) directs and coordinates all commissioning activities and provides Prefunctional Checklists and Functional Test Procedures for Contractor's use.

D. The entire HVAC system is to be commissioned, including commissioning activities for the following specific items:

1. Control system.
2. Major and minor equipment items.
3. Ductwork and accessories.
4. Terminal units.
5. Sound control devices.
7. Variable frequency drives.
8. Special Ventilation:
   a. Fume hoods.
   b. Laboratory pressurization.
   c. Specialty fans.
   d. Egress pressurization.
9. Other equipment and systems explicitly identified elsewhere in Contract Documents as requiring commissioning.
10. Indoor Air Quality Procedures: The Commissioning Authority will coordinate; Contractor will execute; see Section 01734.

E. The Prefunctional Checklist and Functional Test requirements specified in this section are in addition to, not a substitute for, inspection or testing specified in other sections.

1.02 SUBMITTALS

A. See Section 17030 - General Commissioning Requirements, for submittal procedures.
B. HVAC Control System Documentation: Submit detailed sequences of operation, control system drawings, and points list, as specified in Section 17020.

1. Incorporate the sequence of operation information specified in other HVAC specification sections.

2. Incorporate the shop drawing submittal information specified in the HVAC control system section.

3. Submittals prepared for other sections may be used in preparation of this documentation.

C. Updated Submittals: Keep the Commissioning Authority informed of all changes to control system documentation made during programming and setup; revise and resubmit when substantial changes are made.

D. DRAFT Prefunctional Checklists and Functional Test Procedures for Control System: Detailed written plan indicating the procedures to be followed to test, checkout and adjust the control system prior to full system Functional Testing; include at least the following for each type of equipment controlled:

1. System name.

2. List of devices.

3. Step-by-step procedures for testing each controller after installation, including:
   a. Process of verifying proper hardware and wiring installation.
   b. Process of downloading programs to local controllers and verifying that they are addressed correctly.
   c. Process of performing operational checks of each controlled component.
   d. Plan and process for calibrating valve and damper actuators and all sensors.
   e. Description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.

4. Copy of proposed log and field checkout sheets to be used to document the process; include space for initial and final read values during calibration of each point and space to specifically indicate when a sensor or controller has “passed” and is operating within the contract parameters.

5. Description of the instrumentation required for testing.

6. Indicate what tests on what systems should be completed prior to TAB using the control system for TAB work. Coordinate with the Commissioning Authority and TAB contractor for this determination.

E. Startup Reports, Prefunctional Checklists, and Trend Logs: Submit for approval of Commissioning Authority.
F. HVAC Control System O&M Manual Requirements. In addition to documentation specified elsewhere, compile and organize at minimum the following data on the control system:

1. Specific step-by-step instructions on how to perform and apply all functions, features, modes, etc. mentioned in the controls training sections of this specification and other features of this system. Provide an index and clear table of contents. Include the detailed technical manual for programming and customizing control loops and algorithms.

2. Full as-built set of control drawings.

3. Full as-built sequence of operations for each piece of equipment.

4. Full print out of all schedules and set points after testing and acceptance of the system.

5. Full as-built print out of software program.

6. Electronic copy on disk of the entire program for this facility.

7. Marking of all system sensors and thermostats on the as-built floor plan and HVAC drawings with their control system designations.

8. Maintenance instructions, including sensor calibration requirements and methods by sensor type, etc.

9. Control equipment component submittals, parts lists, etc.

10. Warranty requirements.

11. Copies of all checkout tests and calibrations performed by the Contractor (not commissioning tests).

12. Organize and subdivide the manual with permanently labeled tabs for each of the following data in the given order:
   a. Sequences of operation.
   b. Control drawings.
   c. Points lists.
   d. Controller and/or module data.
   e. Thermostats and timers.
   f. Sensors and DP switches.

G. Project Record Documents: See Section 01780 for additional requirements.

1. Submit updated version of control system documentation, for inclusion with operation and maintenance data.

2. Show actual locations of all static and differential pressure sensors (air, water and building pressure) and air-flow stations on project record drawings.
PART 2 PRODUCTS

2.01 TEST EQUIPMENT

A. Provide all standard testing equipment required to perform startup and initial checkout and required functional performance testing; unless otherwise noted such testing equipment will NOT become the property of Owner.

B. Equipment-Specific Tools: Where special testing equipment, tools and instruments are specific to a piece of equipment, are only available from the vendor, and are required in order to accomplish startup or Functional Testing, provide such equipment, tools, and instruments as part of the work at no extra cost to Owner.

PART 3 EXECUTION

3.01 PREPARATION

A. Cooperate with the Commissioning Authority in development of the Prefunctional Checklists and Functional Test Procedures.

B. Furnish additional information requested by the Commissioning Authority.

C. Prepare a preliminary schedule for HVAC pipe and duct system testing, flushing and cleaning, equipment start-up and testing, adjusting, and balancing start and completion for use by the Commissioning Authority; update the schedule as appropriate.

D. Notify the Commissioning Authority when pipe and duct system testing, flushing, cleaning, startup of each piece of equipment and testing, adjusting, and balancing will occur; when commissioning activities not yet performed or not yet scheduled will delay construction notify ahead of time and be proactive in seeing that the Commissioning Authority has the scheduling information needed to efficiently execute the commissioning process.

E. Put all HVAC equipment and systems into operation and continue operation during each working day of testing, adjusting, and balancing and commissioning, as required.
   1. Include cost of sheaves and belts that may be required for testing, adjusting, and balancing.

F. Provide test holes in ducts and plenums where directed to allow air measurements and air balancing; close with an approved plug.

3.02 INSPECTING AND TESTING - GENERAL

A. Submit startup plans, startup reports, and Prefunctional Checklists for each item of equipment or other assembly to be commissioned.

B. Perform the Functional Tests directed by the Commissioning Authority for each item of equipment or other assembly to be commissioned.

C. Provide two-way radios for use during the testing.

D. Valve/Damper Stroke Setup and Check:
   1. For all valve/damper actuator positions checked, verify the actual position against the control system readout.
2. Set pump/fan to normal operating mode.

3. Command valve/damper closed; visually verify that valve/damper is closed and adjust output zero signal as required.

4. Command valve/damper open; verify position is full open and adjust output signal as required.

5. Command valve/damper to a few intermediate positions.

6. If actual valve/damper position does not reasonably correspond, replace actuator or add pilot positioner (for pneumatics).

7. Closure for Heating Coil Valves - Normally Open:
   a. Set heating setpoint 20 degrees F above room temperature.
   b. Observe valve open.
   c. Remove control air or power from the valve and verify that the valve stem and actuator position do not change.
   d. Restore to normal.
   e. Set heating setpoint to 20 degrees F below room temperature.
   f. Observe the valve close.
   g. For pneumatics, by override in the control system, increase pressure to valve by 3 psi (do not exceed actuator pressure rating) and verify valve stem and actuator position does not change.
   h. Restore to normal.

8. Closure for Cooling Coil Valves - Normally Closed:
   a. Set cooling setpoint 20 degrees F above room temperature.
   b. Observe the valve close.
   c. Remove control air or power from the valve and verify that the valve stem and actuator position do not change.
   d. Restore to normal.
   e. Set cooling setpoint to 20 degrees F below room temperature.
   f. Observe valve open.
   g. For pneumatics, by override in the control system, increase pressure to valve by 3 psi (do not exceed actuator pressure rating) and verify valve stem and actuator position does not change.
   h. Restore to normal.
E.  Coil Valve Leak Check:

1. Method 1 - Water Temperature With 2-Way Valve:
   a. Calibrate water temperature sensors on each side of coil to be within 0.2 degree F of each other.
   b. Turn off air handler fans, close outside air dampers. Keep pump running. Make sure appropriate coil dampers are open.
   c. Normally closed valves will close.
   d. Override normally open valves to the closed position.
   e. After 10 minutes observe water delta T across coil. If it is greater than 2 degrees F, leakage is probably occurring.
   f. Reset valve stroke to close tighter.
   g. Repeat test until compliance is achieved.

2. Method 2 - Air Temperature With 2 or 3-Way Valve: Water leak-by less than 10 percent will likely not be detected with this method.
   a. Calibrate air temperature sensors on each side of coil to be within 0.2 degree F of each other.
   b. Air handler fans should be on.
   c. Change mixed or discharge air setpoint, override values or bleed or squeeze bulb pneumatic controller to cause the valve to close.
   d. After 5 minutes observe air delta T across coil. If it is greater than one degree F, leakage is probably occurring.
   e. Reset valve stroke to close tighter.
   f. Repeat test until compliance is achieved.

   a. Put systems in normal mode.
   b. If cooling coil valve, remove all call for cooling; if heating coil valve, put system in full cooling.
   c. Close isolation valve on supply side of coil, open air bleed cap, open drain-down cock and drain water from coil.
   d. If water does not stop draining, there may be a leak through the control valve.
   e. Return all to normal when done.

F. Isolation Valve or System Valve Leak Check: For valves not by coils.

1. With full pressure in the system, command valve closed.
2. Use an ultra-sonic flow meter to detect flow or leakage.

G. Deficiencies: Correct deficiencies and re-inspect or re-test, as applicable, at no extra cost to Owner.
3.03 TAB COORDINATION

A. TAB: Testing, adjusting, and balancing of HVAC.
B. Coordinate commissioning schedule with TAB schedule.
C. Review the TAB plan to determine the capabilities of the control system toward completing TAB.
D. Provide all necessary unique instruments and instruct the TAB technicians in their use; such as handheld control system interface for setting terminal unit boxes, etc.
E. Have all required Prefunctional Checklists, calibrations, startup and component Functional Tests of the system completed and approved by the Commissioning Authority prior to starting TAB.
F. Provide a qualified control system technician to operate the controls to assist the TAB technicians or provide sufficient training for the TAB technicians to operate the system without assistance.

3.04 CONTROL SYSTEM FUNCTIONAL TESTING

A. Prefunctional Checklists for control system components will require a signed and dated certification that all system programming is complete as required to accomplish the requirements of the Contract Documents and the detailed Sequences of Operation documentation submittal.
B. Do not start Functional Testing until all controlled components have themselves been successfully Functionally Tested in accordance with the contract documents.
C. Using a skilled technician who is familiar with this building, execute the Functional Testing of the control system as required by the Commissioning Authority.
D. Functional Testing of the control system constitutes demonstration and trend logging of control points monitored by the control system.
   1. The scope of trend logging is partially specified; trend log up to 50 percent more points than specified at no extra cost to Owner.
   2. Perform all trend logging specified in Prefunctional Checklists and Functional Test procedures.
E. Functionally Test integral or stand-alone controls in conjunction with the Functional Tests of the equipment they are attached to, including any interlocks with other equipment or systems; further testing during control system Functional Test is not required unless specifically indicated below.
F. Demonstrate the following to the Commissioning Authority during testing of controlled equipment; coordinate with commissioning of equipment.
   1. Setpoint changing features and functions.
   2. Sensor calibrations.
G. Demonstrate to the Commissioning Authority:

1. That all specified functions and features are set up, debugged and fully operable.
2. That scheduling features are fully functional and setup, including holidays.
3. That all graphic screens and value readouts are completed.
4. Correct date and time setting in central computer.
5. That field panels read the same time as the central computer; sample 10 percent of field panels; if any of those fail, sample another 10 percent; if any of those fail test all remaining units at no extra cost to Owner.
6. Functionality of field panels using local operator keypads and local ports (plug-ins) using portable computer/keypad; demonstrate 100 percent of panels and 10 percent of ports; if any ports fail, sample another 10 percent; if any of those fail, test all remaining units at no extra cost to Owner.
7. Power failure and battery backup and power-up restart functions.
8. Global commands features.
9. Security and access codes.
10. Occupant over-rides (manual, telephone, key, keypad, etc.).
11. O&M schedules and alarms.
12. Occupancy sensors and controls.
13. Fire alarm interlocks and response.
14. Fire protection and suppression systems interfaces.
15. That points that are monitored only, having no control function, are reporting properly to the control system.
16. All control strategies and sequences not tested during controlled equipment testing.

H. If the control system, integral control components, or related equipment do not respond to changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice, under any of the conditions, sequences, or modes tested, correct all systems, equipment, components, and software required at no additional cost to Owner.

3.05 OPERATION AND MAINTENANCE MANUALS

A. See Section 01780 for additional requirements.
B. Add design intent documentation furnished by Architect to manuals prior to submission to Owner.
C. Submit manuals related to items that were commissioned to Commissioning Authority for review; make changes recommended by Commissioning Authority.

D. Commissioning Authority will add commissioning records to manuals after submission to Owner.

3.06 DEMONSTRATION AND TRAINING

A. Demonstrate operation and maintenance of HVAC system to Owner's personnel; if during any demonstration, the system fails to perform in accordance with the information included in the O&M manual, stop demonstration, repair or adjust, and repeat demonstration. Demonstrations may be combined with training sessions if appropriate.

B. These demonstrations are in addition to, and not a substitute for, Prefunctional Checklists and demonstrations to the Commissioning Authority during Functional Testing.

C. Provide classroom and hands-on training of Owner's designated personnel on operation and maintenance of the HVAC system, control system, and all equipment items indicated to be commissioned. Provide the following minimum durations of training:

1. HVAC Control System: 40 hours.
2. Chillers and System: 8 hours.
3. Cooling Towers: 8 hours.
4. Boilers and System: 8 hours.
5. Chemical Treatment: 4 hours.
6. Control Air Compressors and Dryers: 4 hours.
7. Air Handling Units: 4 hours.
8. Variable Speed Drives: 8 hours.
9. Supplementary Supply Fans: 4 hours.
10. Return Fan/Relief Fan: 4 hours.
11. Air Terminal Units: 4 hours.
12. Packaged Rooftop Units: 8 hours.
13. Computer Room AC Units: 8 hours.
14. Split System AC or Heat Pumps: 3 hours.
15. Spot AC Units: 2 hours.
16. Spot Unit Heaters: 2 hours.
17. Elevator Shaft Fans: 2 hours.
18. Stairwell Fans: 4 hours.
19. Specialty Exhaust Fans: 4 hours.
20. Restroom Central Exhaust Fans: 2 hours.


D. TAB Review: Instruct Owner's personnel for minimum 16 hours, after completion of TAB, on the following:

1. Review final TAB report, explaining the layout and meanings of each data type.
2. Discuss any outstanding deficient items in control, ducting or design that may affect the proper delivery of air or water.
3. Identify and discuss any terminal units, duct runs, diffusers, coils, fans and pumps that are close to or are not meeting their design capacity.
4. Discuss any temporary settings and steps to finalize them for any areas that are not finished.
5. Other salient information that may be useful for facility operations, relative to TAB.

E. HVAC Control System Training: Perform training in at least three phases:

1. Phase 1 - Basic Control System: Provide minimum of 16 hours of actual training on the control system itself. Upon completion of training, each attendee, using appropriate documentation, should be able to perform elementary operations and describe general hardware architecture and functionality of the system.
   a. This training may be held on-site or at the manufacturer's facility.
   b. If held off-site, the training may occur prior to final completion of the system installation.
   c. For off-site training, Contractor shall pay expenses of up to 4 attendees.
2. Phase 2 - Integrating with HVAC Systems: Provide minimum of 24 hours of on-site, hands-on training after completion of Functional Testing. Include instruction on:
   a. The specific hardware configuration of installed systems in this facility and specific instruction for operating the installed system, including interfaces with other systems, if any.
   b. Security levels, alarms, system start-up, shut-down, power outage and restart routines, changing setpoints and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.
c. Trend logging and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular and graphically and printing trends; provide practice in setting up trend logging and monitoring during training session.

d. Every display screen, allowing time for questions.

e. Point database entry and modifications.

3. Phase 3 - Post-Occupancy: 9 months after occupancy conduct minimum of 16 hours of training. Tailor training session to questions and topics solicited beforehand from Owner. Also be prepared to address topics brought up and answer questions concerning operation of the system.

F. Provide the services of manufacturer representatives to assist instructors where necessary.

G. Provide the services of the HVAC controls instructor at other training sessions, when requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

END OF SECTION
## REQUEST FOR PROPOSAL

### AUTOMATIC TEMPERATURE CONTROLS

INDEFINITE DELIVERY INDEFINITE QUANTITY (IDIQ)
NEW AND EXISTING BUILDINGS.
UNIVERSITY OF ARKANSAS CAMPUS
FAYETTEVILLE, ARKANSAS

STANDARD CONTROL SYSTEM DRAWINGS

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### HYDRONIC FLOW METER

- **Legend**
- **Flow**

**NOT TO SCALE**

**NOTE**
Install a horizontal OA/vertical RH, down flow is not permitted. Note flow arrow in direction of flow. Refer to installation instructions for additional details.

### STEAM FLOW METER INSTALLATION DETAIL

- **Legend**
- **Duct Width**

**NOT TO SCALE**

**NOTE**
Mechanical contractor responsible for pipe taps and hard valves. Install taps on sides of pipe, not bottom or top.

### HYDRONIC AND STEAM CONDENSATE RETURN DIFFERENTIAL PRESSURE TRANSMITTER

- **Legend**
- **Duct Width**

**NOT TO SCALE**

**NOTE**
Mechanical contractor responsible for pipe taps and hard valves. Install taps on sides of pipe, not bottom or top.

### SCHEMATIC PIPING REPRESENTATION

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### ADDITIONAL DETAILS

1. **Flow Meter**
2. **Duct Flow Switch**
3. **Control Damper**
4. **Differential Pressure Sensor**
5. **Differential Pressure Transmitter**
6. **Fan Coil Unit**
7. **Fan Controller**
8. **Heat Exchanger**
9. **Humidifier**

### STANDARD SYSTEM DRAWINGS

**LEGEND AND DETAILS**

**NOT TO SCALE**

**NOTE**
Not to scale.
LOCATE SENSOR DOWNSTREAM OF DE-COUPLER AS FAR AS POSSIBLE – MINIMUM DISTANCE 10'-0".

BUILDING CHILL WATER SYSTEM SEQUENCE OF OPERATION:

**MODE OF OPERATION**:

The mode of operation for the building chill water system shall be either pressure control, or temperature control. The mode of operation shall typically be pressure control. Temperature control mode of operation shall only be used in the event of a low building chill water temperature difference that cannot be immediately rectified. The mode of operation shall be selected at the DDC controls panel. When the mode of operation is pressure control, the temperature control valve shall be closed. If the temperature control valve is open, the mode of operation is temperature control. The two position control valve in the de-coupler must be open.

**BUILDING CHILL WATER DIFFERENTIAL PRESSURE SETPOINT**: The building chill water differential pressure setpoint shall be fixed and shall be enabled or disabled by the operator or a remote process.

**BUILDING CHILL WATER VOLUMETRIC CONTRACT DEMAND**: Building chill water volumetric contract demand shall be adjustable, and shall be enabled or disabled by the operator or a remote process.

**BUILDING CHILL WATER CONTROL VALVE AND PUMP(S)**: When building cooling is disabled, the building chill water valve shall be closed and the pump(s) shall be commanded off. Building cooling shall be enabled and disabled based upon operator command.

**PRESSURE CONTROL**: When in the pressure control mode, the building chill water valve shall be modulated to maintain the building differential pressure at set point. If the building differential pressure is more than 0.5% adjustable below the building differential pressure set point and the building chill water valve is more than 95% open, the building chill water valve shall be modulated fully open, and the building chill water pump operation shall be enabled. When the building chill water pump has been commanded on, the pump speed shall be modulated from a minimum of 20% (adjustable) to a maximum of 100% (adjustable), and the building differential pressure is at or above set point for more than 10 minutes (adjustable), the building chill water valve shall be modulated to maintain the pressure and the pump speed shall be modulated from 25% (adjustable) to 100% (adjustable) as required to maintain the building differential pressure at set point. The building differential pressure set point shall be overridden as required to prevent the building chill water flow from exceeding the building volumetric contract demand and the building chill water refrigeration from exceeding the building refrigeration contract demand. The set point shall reset down as the limits are approached, decreasing the speed of the pump or decreasing flow through the building chill water valve.

**TEMPERATURE CONTROL**: When in the temperature control mode, the building chill water valve shall be modulated to maintain the building chill water return temperature at set point of 54 deg. F (adjustable). The building chill water pump shall be started and the pump speed shall be modulated from a minimum of 20% (adjustable) to a maximum of 100% (adjustable) as required to maintain building differential pressure at set point. The building differential pressure set point shall be overridden as required to prevent the building chill water flow from exceeding the building chill water volumetric contract demand and the building chill water refrigeration from exceeding the building refrigeration contract demand.

STANDARD SYSTEM DRAWINGS

RFP - ATC IDIQ
UNIVERSITY OF ARKANSAS
FAYETTEVILLE, ARKANSAS

CHILL WATER SYSTEM

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SEQUENCE OF OPERATION:

HOT WATER PUMP CONTROL:  THE OPERATOR SELECTED LEAD HOT WATER PUMP SHALL AUTOMATICALLY START WHEN THE OUTSIDE AIR TEMPERATURE FALLS BELOW THE SYSTEM ENABLE SETPOINT.  WHEN THE OUTSIDE AIR TEMPERATURE RISES ABOVE THIS SETPOINT PLUS A DIFFERENTIAL, THE HOT WATER PUMP SHALL TURN OFF.  WHEN ENABLED, THE PUMP SHALL START AND RUN CONTINUOUSLY.  WHILE RUNNING THE HOT WATER PUMP SHALL MODULATE TO MAINTAIN THE HOT WATER DIFFERENTIAL PRESSURE AT SETPOINT.  IF FOR ANY REASON ITS STATUS DOES NOT MATCH ITS COMMANDED VALUE AN ALARM SHALL BE GENERATED.  THE LAG PUMP SHALL START IF THE LEAD PUMP IS AN ALARM.

STEAM CONTROL VALVES:  THE LEAD HEAT EXCHANGER STEAM CONTROL VALVES SHALL MODULATE IN A 1/3 - 2/3 CAPACITY CONFIGURATION TO MAINTAIN THE HOT WATER SUPPLY TEMPERATURE AT A SETPOINT THAT IS RESET INVERSELY TO THE OUTSIDE AIR TEMPERATURE WHEN EITHER HOT WATER PUMP HAS A STATUS OF ON.  2/3 VALVE OPERATES ONLY AFTER 1/3 VALVE HAS MODULATED OPEN.  VALVE CONTROL SHALL BE OVERRIDDEN TO PREVENT THE CONVERTER LEAVING WATER TEMPERATURE FROM EXCEEDING 200 DEG F.

HW CONTROL VALVE:  CONTROL VALVE IN RETURN WATER TO HEAT EXCHANGER SHALL OPEN WHEN HEAT EXCHANGER IS OPERATIVE AND CLOSE WHEN HEAT EXCHANGER IS NOT OPERATING.

STEAM SYSTEM:  BUILDING STEAM USAGE IS MEASURED BY A FLOW METER WITH FLOW TRANSMITTER.  BUILDING STEAM FLOW IS TOTALIZED. STEAM PRESSURE AND RELIEF VALVE OPERATION SHALL BE MONITORED BY DDCC CONTROLLER THROUGH TEMPERATURE SENSOR AT RELIEF PIPING.
SEQUENCE OF OPERATION:

SUPPLY FAN: STARTED AND STOPPED THROUGH PUSHBUTTONS AT THE VFD. OPERATOR COMMAND, OR WEEKLY OCCUPIED / UNOCCUPIED SCHEDULE. THE FAN SHALL BE AUTOMATICALLY STOPPED BY THE FIRE ALARM PANEL, HIGH PRESSURE ALARM, OR THE LOW LIMIT ALARM IN THE EVENT OF AN UNSAFE OR ALARM CONDITION. THE FAN VFD SHALL BE MODULATED TO MAINTAIN A DISCHARGE AIR STATIC PRESSURE SET POINT AS ESTABLISHED BY THE TEST AND BALANCE CONTRACTOR. THE SPEED SHALL MODULATE TO OVERCOME SYSTEM PRESSURE DROPS (FILTER LOADING).

CHILL WATER CONTROL VALVE: WHEN THE FAN IS IN OPERATION, THE CHILL WATER CONTROL VALVE SHALL MODULATE AS REQUIRED TO MAINTAIN THE SPACE TEMPERATURE AT SET POINT (ADJUSTED AT THE THERMOSTAT) VIA SPACE RESET OF DISCHARGE AIR TEMPERATURE. THE CHILL WATER VALVES SHALL CLOSE WHEN THE SUPPLY FAN IS NOT IN OPERATION. IF THE LOW LIMIT TRIPS, THE CHILL WATER VALVES SHALL OPEN FULLY TO FLOW THROUGH THE COIL.

HEATING WATER CONTROL VALVE: WHEN THE FAN IS IN OPERATION, THE HEATING WATER CONTROL VALVE SHALL MODULATE AS REQUIRED TO MAINTAIN THE SPACE TEMPERATURE AT SET POINT (ADJUSTED AT THE THERMOSTAT) VIA SPACE RESET OF DISCHARGE AIR TEMPERATURE. THE HEATING WATER VALVE SHALL CLOSE WHEN THE SUPPLY FAN IS NOT IN OPERATION. IF THE LOW LIMIT TRIPS, THE HEATING WATER VALVE SHALL OPEN FULLY TO FLOW THROUGH THE COIL.

SEQUENCE OF OPERATION

SUPPLY FAN STARTED AND STOPPED THROUGH PUSHBUTTONS AT THE VFD OPERATOR COMMAND, OR BY THE DEVICES BASED UPON A WEEKLY OCCUPIED / UNOCCUPIED SCHEDULE. THE FAN SHALL BE AUTOMATICALLY STOPPED BY THE FIRE ALARM PANEL, HIGH STATIC PRESSURE ALARM, OR THE LOW LIMIT IN THE EVENT OF AN UNSAFE OR ALARM CONDITION. THE SPEED SHALL MODULATE TO MAINTAIN THE SYSTEM PRESSURE DEMAND (FILTER LOADING).

PREHEAT WATER CONTROL VALVE: WHEN THE FAN IS IN OPERATION, THE PREHEAT CONTROL VALVE SHALL MODULATE AS REQUIRED TO MAINTAIN LEAVING AIR TEMPERATURE AT SET POINT (50 DEG. F. ADJUSTABLE). THE PREHEAT CONTROL VALVE SHALL OPEN FULLY TO FLOW THROUGH THE COIL.

CHILL WATER CONTROL VALVE: WHEN THE FAN IS IN OPERATION, THE CHILL WATER CONTROL VALVE SHALL MODULATE AS REQUIRED TO MAINTAIN THE SPACE TEMPERATURE AT SET POINT. THE CHILL WATER VALVE SHALL CLOSE WHEN THE SUPPLY FAN IS NOT IN OPERATION. IF THE LOW LIMIT TRIPS, THE CHILL WATER VALVE SHALL OPEN FULLY TO FLOW THROUGH THE COIL.

RE-HEAT WATER CONTROL VALVE: WHEN THE FAN IS IN OPERATION, THE HEATING WATER CONTROL VALVE SHALL MODULATE AS REQUIRED TO MAINTAIN THE SPACE TEMPERATURE AT SET POINT. THE HEATING WATER VALVE SHALL CLOSE WHEN THE SUPPLY FAN IS NOT IN OPERATION. IF THE LOW LIMIT TRIPS, THE HEATING WATER VALVE SHALL OPEN FULLY TO FLOW THROUGH THE COIL.


HUMIDITY CONTROL: THE CHILL WATER VALVE SHALL MODULATE THROUGH HUMIDITY HIGH LIMIT (MAX 85% RH) TO MAINTAIN RETURN AIR HUMIDITY SET POINT (45% RH ADJUSTABLE).

SUPPLY FAN STARTED AND STOPPED THROUGH PUSHBUTTONS AT THE VFD OPERATOR COMMAND, OR BY THE DEVICES BASED UPON A WEEKLY OCCUPIED / UNOCCUPIED SCHEDULE. THE FAN SHALL BE AUTOMATICALLY STOPPED BY THE FIRE ALARM PANEL, HIGH STATIC PRESSURE ALARM, OR THE LOW LIMIT IN THE EVENT OF AN UNSAFE OR ALARM CONDITION. THE SPEED SHALL MODULATE TO MAINTAIN THE SYSTEM PRESSURE DEMAND (FILTER LOADING).

PREHEAT WATER CONTROL VALVE: WHEN THE FAN IS IN OPERATION, THE PREHEAT CONTROL VALVE SHALL MODULATE AS REQUIRED TO MAINTAIN LEAVING AIR TEMPERATURE AT SET POINT (50 DEG. F. ADJUSTABLE). THE PREHEAT CONTROL VALVE SHALL OPEN FULLY TO FLOW THROUGH THE COIL.

CHILL WATER CONTROL VALVE: WHEN THE FAN IS IN OPERATION, THE CHILL WATER CONTROL VALVE SHALL MODULATE AS REQUIRED TO MAINTAIN THE SPACE TEMPERATURE AT SET POINT. THE CHILL WATER VALVE SHALL CLOSE WHEN THE SUPPLY FAN IS NOT IN OPERATION. IF THE LOW LIMIT TRIPS, THE CHILL WATER VALVE SHALL OPEN FULLY TO FLOW THROUGH THE COIL.

RE-HEAT WATER CONTROL VALVE: WHEN THE FAN IS IN OPERATION, THE HEATING WATER CONTROL VALVE SHALL MODULATE AS REQUIRED TO MAINTAIN THE SPACE TEMPERATURE AT SET POINT. THE HEATING WATER VALVE SHALL CLOSE WHEN THE SUPPLY FAN IS NOT IN OPERATION. IF THE LOW LIMIT TRIPS, THE HEATING WATER VALVE SHALL OPEN FULLY TO FLOW THROUGH THE COIL.


HUMIDITY CONTROL: THE CHILL WATER VALVE SHALL MODULATE THROUGH HUMIDITY HIGH LIMIT (MAX 85% RH) TO MAINTAIN RETURN AIR HUMIDITY SET POINT (45% RH ADJUSTABLE).
**Outside Air**

- **Outside Air Damper (DMPR)**
- **Outside Air Temperature (T/B/D)**
- **Return Air**

**NOTE:** MINIMUM DISTANCE BETWEEN WATER COILS IS 24" WITH ACCESS DOOR

**Sequence of Operation**

- **Supply Fan:** The supply fan shall be started and stopped by the push button switch at the fan variable frequency drive. When the switch is in the local position, the fan shall be started and stopped locally at the VFD. When the switch is in the auto position, the fan shall be started and stopped by the DDC controller based upon a weekly schedule, operator command, or when any of the associated VAV boxes are occupied or temporary override. The supply fan shall be automatically stopped by the fire alarm system, low limit switch, or supply air high static pressure alarm whenever an unsafe condition occurs. Status of the supply fan shall be monitored by the DDC controller. The speed of the supply fan shall be modulated to maintain the duct static pressure at set point (1.0" WC adjustable).

- **Outside Air Damper:**
  - The outside air damper shall provide the scheduled amount of outside air (set by the test and balance contractor). The return air CO2 sensor shall modulate the outside air damper to maintain set point. The mixed air sensor shall override the outside damper closed to maintain a minimum set point (35 degrees, adjustable). The outside air damper shall close when the unit is not in operation.

- **Chilled Water and Heating Water Valves:** The chilled water and the heating water control valves shall modulate in sequence to maintain the supply air temperature at set point. The set point is 55 deg. F (adjustable). The valves shall close when the supply fan is not in operation. Upon a low limit trip, the valves shall both open fully to flow through the coil.

- **Filters:** The filter pressure drop shall be monitored by filter alarm from a differential pressure switch. If pressure drop exceeds the set point (5 Psi, local adjustment), an alarm shall be sent to operator station.

**Diagram Description**

- **Outside Air**
- **Return Air**
- **Outside Air Temperature (T/B/D)**
- **Return Air Temperature**
- **Return Air CO2**
- **Supply Fan**
- **Outside Air Damper**
- **Chilled Water Return Temperature**
- **VFD Speed Output**
- **VFD Fan Status**
- **High Pressure Alarm**
- **Duct Static Pressure**
- **Return Air Temperature**
- **Return Air CO2**

**Job Name:** VARIABLE AIR VOLUME AHU

**System/Description**

**I/O Point Matrix**

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<th>System/Description</th>
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**NOTE:** Minimum distance between water coils is 24" with access door.

**Diagram Elements**

- **Location to be shown on mechanical drawings - selected by engineer**
- **Hardwire interlock with fan VFD**
- **Spare sensor pipe well**

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SEQUENCE OF OPERATION:


HOT DECK: THE STEAM CONTROL VALVES SHALL BE MODULATED IN SEQUENCE BY THE DIGITAL CONTROLLER ANALOG OUTPUT TO MAINTAIN THE HOT DECK TEMPERATURE AT SETPOINT. SETPOINT SHALL BE RESET BASED ON OUTSIDE AIR TEMPERATURE FROM 110 DEGREES AT 40 DEGREES OUTSIDE AIR TO 80 DEGREES AT 70 DEGREES OUTSIDE AIR.

COLD DECK: THE CHILL WATER CONTROL VALVE SHALL BE MODULATED BY THE DIGITAL CONTROLLER ANALOG OUTPUT TO MAINTAIN THE COLD DECK TEMPERATURE AT SETPOINT (55 DEGREES ADJUSTABLE).

OUTSIDE AIR DAMPER: THE OUTSIDE AIR DAMPER SHALL BE OPENED TO A MINIMUM POSITION WHEN THE SUPPLY FAN IS ON. THE MINIMUM POSITION SHALL BE 5%. THE DAMPER SHALL CLOSE WHEN THE UNIT IS OFF.

FILTERS: THE FILTER PRESSURE DROP SHALL BE MONITORED BY THE DIGITAL CONTROLLER DIGITAL INPUT FROM A DIFFERENTIAL PRESSURE SWITCH. IF THE PRESSURE DROP EXCEEDS THE SETPOINT (0.5"WG ADJUSTABLE) AN ALARM SHALL BE GENERATED.

EXHAUST FAN: EXHAUST FAN SHALL BE COMMANDED ON WHEN AHU IS ON AND OFF WHEN AHU IS OFF.
SEQUENCE OF OPERATION: ENERGY RECOVERY UNIT

SYSTEM START/STOP CONTROL: THE UNIT SHALL BE STARTED AND STOPPED THROUGH AN ON/OFF COMMAND FROM THE DDC CONTROL PANEL. THE UNIT SHALL BE ENABLED OR DISABLED SUBJECT TO AN OPERATOR COMMAND OR SAFETY CIRCUIT TRIP.

SYSTEM "OFF" MODE: THE SUPPLY AND EXHAUST FANS SHALL BE OFF. THE ENERGY WHEEL SHALL BE STOPPED. THE OUTDOOR AND EXHAUST DAMPERS SHALL BE CLOSING, AND THE HEATING AND COOLING VALVES SHALL BE CLOSED TO THE COL.

SYSTEM "ON" MODE: THE OUTSIDE AIR AND EXHAUST AIR DAMPERS, WHEN THE ENERGY RECOVERY SYSTEM IS ENABLED, ARE OPENED THROUGH THE ENERGY RECOVERY CONTROL SYSTEM (PROVIDED WITH UNIT). WHEN THE SYSTEM IS DISABLED, THE DAMPERS ARE CLOSED. THE HEATING AND COOLING COIL CONTROL SHALL MODULATE IN SEQUENCE TO MAINTAIN THE UNIT DISCHARGE AIR TEMPERATURE AT ITS RESET SET POINT.

UNIT DISCHARGE AIR TEMPERATURE SET POINT: THE LEAVING EXHAUST AIR TEMPERATURE SET POINT SHALL BE RESET BASED ON FOLLOWING SCHEDULE.

- OAT (DEG. F.): 35 DEG. F. - 75 DEG. F.
- SUPPLY AIR TEMPERATURE (DEG. F.):
  - 35 DEG. F.
- SUPPLY AIR HUMIDITY:
  - 50% RH.
- SUPPLY DUCT PRESSURE (IN. WG.):
  - 5 IN. WG.
- LEAVING EXHAUST AIR TEMPERATURE (DEG. F.):
  - 50 DEG. F.
- EXHAUST AIR TEMPERATURE:
  - 50 DEG. F.
- EXHAUST AIR HUMIDITY:
  - 50% RH.
- OUTSIDE AIR FLOW (CFM):
  - 0 CFM.
- CHILL WATER TEMPERATURE:
  - 35 DEG. F.


SUPPLY AIR TEMPERATURE:
- SUPPLY AIR TEMPERATURE (DEG. F.)
  - 35 DEG. F.
- SUPPLY AIR HUMIDITY:
  - 50% RH.
- SUPPLY DUCT PRESSURE (IN. WG.):
  - 5 IN. WG.
- LEAVING EXHAUST AIR TEMPERATURE (DEG. F.):
  - 50 DEG. F.
- EXHAUST AIR TEMPERATURE:
  - 50 DEG. F.
- EXHAUST AIR HUMIDITY:
  - 50% RH.
- OUTSIDE AIR FLOW (CFM):
  - 0 CFM.
- CHILL WATER TEMPERATURE:
  - 35 DEG. F.

EXHAUST FILTER ALARM: AN ALARM SHALL BE GENERATED AT THE DDC CONTROL PANEL IF ANY OF THE FOLLOWING OCCUR: (1) ENERGY WHEEL FAILURE, (2) SUPPLY FAN FAILURE TO START, (3) EXHAUST FAN FAILURE TO START, (4) EXCESSIVE FILTER PRESSURE DROP, AND (5) VFD FAULT.
NOTE: MINIMUM DISTANCE BETWEEN CHILL WATER AND HEATING WATER COILS IS 24" WITH ACCESS DOOR.

SEQUENCE OF OPERATION:
SUPPLY FAN: STARTED AND STOPPED THROUGH PUSHBUTTONS AT THE VFD, OPERATOR COMMAND, OR BY THE DDC PANEL BASED UPON A WEEKLY OCCUPIED/UNOCCUPIED SCHEDULE. FAN SHALL NOT START UNTIL OUTSIDE AIR DAMPER IS PROVEN OPEN AT END SWITCH. THE FAN SHALL BE AUTOMATICALLY STOPPED BY THE FIRE ALARM PANEL, HIGH STATIC PRESSURE ALARM OR THE LOW LIMIT IN THE EVENT OF AN UNSAFE OR ALARM CONDITION. THE FAN VFD SHALL BE MODULATED TO MAINTAIN OUTSIDE AIR FLOW SETPOINT.

CHILL WATER CONTROL VALVES: WHEN THE FAN IS IN OPERATION, THE CHILL WATER CONTROL VALVES SHALL MODULATE AS REQUIRED TO MAINTAIN THE DISCHARGE AIR TEMPERATURE SETPOINT. THE CHILL WATER VALVES SHALL CLOSE WHEN THE SUPPLY FAN IS NOT IN OPERATION. IF THE LOW LIMIT TRIPS, THE CHILL WATER VALVES SHALL OPEN FULLY TO FLOW THROUGH THE COIL.

HEATING CONTROL: WHEN THE FAN IS IN OPERATION, THE FACE AND BYPASS DAMPERS AND STEAM COIL VALVES SHALL MODULATE AT OUTDOOR TEMPERATURES ABOVE 40 DEG. F. TO MAINTAIN DISCHARGE TEMPERATURE SETPOINT. WHEN OUTDOOR TEMPERATURES ARE BELOW 40 DEG. F., THE STEAM COIL VALVE SHALL BE AT 100%, THE FACE DAMPER SHALL BE FULL OPEN, AND THE BYPASS DAMPER SHALL MODULATE TO MAINTAIN DISCHARGE TEMPERATURE SETPOINT.

OUTSIDE AIR DAMPER: WHEN THE SUPPLY FAN IS IN OPERATION, THE OUTSIDE AIR DAMPER SHALL OPEN. DAMPER SHALL CLOSE WHEN FAN IS OFF.

### I/O Point Matrix

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<td>PNEUMATIC TRANSDUCER</td>
<td></td>
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</table>

### Analog/Digital Device Tracking

- INPUT DEVICE
- OUTPUT DEVICE

- ANALOG TRACKING
- DIGITAL TRACKING

**Drawing Name:** AHU-OSA

**Constant Volume AHU - 100% OSA**

**Notes:**
- MINIMUM DISTANCE BETWEEN CHILL WATER AND HEATING WATER COILS IS 24" WITH ACCESS DOOR.
- CHILL WATER AND HEATING WATER COILS ARE 24" WITH ACCESS DOOR.

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- Suite 300 PMB 324
- Little Rock, AR 72223
- Phone 501-448-0100
- www.brownengineers.net

**RFP - ATC IDIQ**
- UNIVERSITY OF ARKANSAS
- FAYETTEVILLE, ARKANSAS
- STANDARD SYSTEM DRAWINGS

**Job Name:**
- CONSTANT VOLUME AHU - 100% OSA

**Drawing Number:**
- AHU-OSA
SEQUENCE OF OPERATION
FAN COIL UNIT: FAN OPERATION SHALL BE ENABLED/DISABLED THROUGH DDC CONTROL PANEL. FAN SHALL OPERATE THROUGH MANUFACTURER'S ECM CONTROLLER. MODULATE THE WATER CONTROL VALVE AS REQUIRED TO MAINTAIN THE SPACE TEMPERATURE AT SETPOINT (ADJUSTABLE). SUMMER/WINTER OPERATION SHALL BE INDEXED BY CALENDAR SCHEDULE.

MODES OF OPERATION
- FAN COIL MODE OF OPERATION IS EITHER "OCUPIED", "STANDBY", OR "UNOCCUPIED": OCCUPIED AND UNOCCUPIED MODES ARE DETERMINED BASED ON A CALENDAR AND TIME OF DAY SCHEDULE. STANDBY MODE IS DETERMINED DURING THE OCCUPIED MODE WITH INPUT FROM OCCUPANCY SENSOR. UNOCCUPIED MODE CAN BE OVERRIDDEN TO OCCUPIED MODE BY EITHER BUTTON AT THERMOSTAT FOR 2 HOURS (ADJUSTABLE) OR BY OCCUPANCY SENSOR.
- STANDBY MODE: WHEN A SPACE MOTION DETECTOR IS PRESENT AND SENSES OCCUPANCY, MODE OF OPERATION SHALL BE "OCUPIED." IF SENSOR DOES NOT SENSE OCCUPANCY, THEN SPACE WILL BE IN STANDBY MODE. DURING THE "STANDBY" MODE OF OPERATION, THE SET POINT SHALL BE ADJUSTED THROUGH THE DDC CONTROL PANEL BETWEEN A MINIMUM OF 71 DEG. F AND MAXIMUM OF 75 DEG. F. THERE SHALL BE A 3 DEG. F. DEAD BAND ON EITHER SIDE OF THE SETPOINT.
SEQUENCE OF OPERATION

4-PIPE FAN COIL UNIT: FAN OPERATION SHALL BE ENABLED/DISABLED THROUGH DDC CONTROL PANEL. FAN SHALL OPERATE THROUGH MANUFACTURER'S ECM CONTROLLER. MODULATE THE HEATING AND CHILL WATER CONTROL VALVES AS REQUIRED TO MAINTAIN THE SPACE TEMPERATURE AT SETPOINT (ADJUSTABLE). SUMMER/WINTER OPERATION SHALL BE INDEXED BY CALENDAR SCHEDULE.

MODES OF OPERATION: FAN COIL MODE OF OPERATION IS EITHER "OCCUPIED", "STANDBY" OR "UNOCCUPIED". OCCUPIED AND UNOCCUPIED MODES ARE DETERMINED BASED ON A CALENDAR AND TIME OF DAY SCHEDULE. STANDBY MODE IS DETERMINED DURING THE OCCUPIED MODE WITH INPUT FROM OCCUPANCY SENSOR. UNOCCUPIED MODE CAN BE OVERRIDDEN TO OCCUPIED MODE BY EITHER BUTTON AT THERMOSTAT FOR 2 HOURS (ADJUSTABLE) OR BY OCCUPANCY SENSOR.


STANDBY MODE: WHEN A SPACE MOTION DETECTOR IS PRESENT AND SENSES OCCUPANCY, MODE OF OPERATION SHALL BE "OCCUPIED." IF SENSOR DOES NOT SENSE OCCUPANCY, THEN SPACE WILL BE IN STANDBY MODE. DURING THE "STANDBY" MODE OF OPERATION, THE SET POINT SHALL BE ADJUSTED THROUGH THE DDC CONTROL PANEL BETWEEN A MINIMUM OF 71 DEG. F AND A MAXIMUM OF 75 DEG. F. THERE SHALL BE A 6 DEG. F. DEAD BAND ON EITHER SIDE OF THE SETPOINT.


SYSTEM / DESCRIPTION

<table>
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<th>DIGITAL</th>
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<tbody>
<tr>
<td>FAN START/STOP</td>
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<tr>
<td>DISCHARGE AIR TEMPERATURE</td>
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<tr>
<td>HEATING COIL VALVE OUTPUT</td>
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<td>ZONE TEMPERATURE</td>
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<tr>
<td>REMOTE SETPOINT</td>
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<tr>
<td>MOTION SENSOR</td>
<td></td>
<td></td>
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</table>
SEQUENCE OF OPERATION:

4-PIPE FAN COIL UNIT: FAN OPERATION SHALL BE ENABLED/DISABLED THROUGH DDC CONTROL PANEL. OPERATE THROUGH MANUFACTURER’S ECM CONTROLLER. MODULATE THE HEATING AND CHILL WATER CONTROL VALVES AS REQUIRED TO MAINTAIN THE RETURN TEMPERATURE AT SET POINT (ADJUSTABLE).

1. MODES OF OPERATION: FAN COIL MODE OF OPERATION IS EITHER "OCCUPIED", "STANDBY", OR "UNOCCUPIED": OCCUPIED AND UNOCCUPIED MODES ARE DETERMINED BASED ON A CALENDAR AND TIME OF DAY SCHEDULE. STANDBY MODE IS DETERMINED DURING THE OCCUPIED MODE WITH INPUT FROM OCCUPANCY SENSOR. UNOCCUPIED MODE CAN BE OVERRIDDEN TO OCCUPIED MODE BY EITHER BUTTON AT THERMOSTAT FOR 2 HOURS (ADJUSTABLE) OR BY OCCUPANCY SENSOR.


3. STANDBY MODE: WHEN A SPACE MOTION DETECTOR IS PRESENT AND SENSES OCCUPANCY, MODE OF OPERATION SHALL BE "OCCUPIED". IF SENSOR DOES NOT SENSE OCCUPANCY, THEN SPACE WILL BE IN STANDBY MODE. DURING THE "STANDBY" MODE OF OPERATION, THE SET POINT SHALL BE ADJUSTED THROUGH THE DDC CONTROL PANEL BETWEEN A MINIMUM OF 71° F AND MAXIMUM OF 75° F. THERE SHALL BE A 3° F DEAD BAND ON EITHER SIDE OF THE SETPOINT.


JOB NAME: FAN COIL UNIT - 4 PIPE RETURN AIR CONTROL

SYSTEM / DESCRIPTION:

RETURN AIR TEMPERATURE
FAN START/STOP
HEATING VALVE OUTPUT
COOLING VALVE OUTPUT
DISCHARGE AIR TEMPERATURE
MOTION SENSOR

RETURN AIR CONTROL

DISCHARGE AIR
Sequence of Operation:

**Cooling Mode:** When the space sensor increases two degrees above set point, the controller shall be commanded to the cooling mode. The chill water valve shall modulate to maintain 55 degrees constant discharge temperature. Fan operation shall be enabled/disabled through DDC control panel. Fan shall operate through manufacturer's ECM controller.

**Heating Mode:** When the space sensor decreases two degrees below set point, the controller shall be commanded to the heating mode. Fan operation shall be enabled on and the heating water valve shall be modulated to maintain space temperature at set point. Fan shall operate through manufacturer's ECM controller.

**Modes of Operation:**

- **Occupied Mode:** During the "Occupied" mode of operation, the set point shall be adjusted through the DDC control panel between a minimum of 71 deg. F and maximum of 75 deg. F. There shall be a 1 deg. F dead band on either side of the setpoint.

- **Standby Mode:** When a space motion detector is present and senses occupancy, mode of operation shall be "Occupied." If sensor does not sense occupancy, then space will be in "Standby" mode. During the "Standby" mode of operation, the set point shall be adjusted through the DDC control panel between a minimum of 71 deg. F and maximum of 75 deg. F. There shall be a 1 deg. F dead band on either side of the setpoint.

- **Unoccupied Mode:** During the "Unoccupied" mode of operation, the set point shall be adjusted through the DDC control panel between a minimum of 71 deg. F and maximum of 75 deg. F. There shall be a 1 deg. F dead band on either side of the setpoint.

**I/O Point Matrix**

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<tr>
<th>Device Type</th>
<th>Input Device</th>
<th>Output Device</th>
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<tbody>
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<td>Fan Start/Stop</td>
<td>Analog Input</td>
<td>Digital Output</td>
</tr>
<tr>
<td>Fan Status</td>
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<td></td>
</tr>
<tr>
<td>Discharge Air Temperature</td>
<td>Analog Input</td>
<td>Digital Output</td>
</tr>
<tr>
<td>Heating Coil Valve Output</td>
<td>Analog Input</td>
<td>Digital Output</td>
</tr>
<tr>
<td>Cooling Coil Valve Output</td>
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<tr>
<td>Remote Setpoint</td>
<td>Analog Input</td>
<td>Digital Output</td>
</tr>
<tr>
<td>Motion Sensor</td>
<td>Analog Input</td>
<td>Digital Output</td>
</tr>
</tbody>
</table>
SEQUENCE OF OPERATION:

COOLING ONLY: BLOWER COIL UNIT FAN SHALL BE STARTED AND STOPPED THROUGH DDC CONTROL PANEL. THE FAN SHALL TYPICALLY BE OPERATED AT ALL TIMES. MODULATE THE CHILL WATER CONTROL VALVE AS REQUIRED TO MAINTAIN THE SPACE TEMPERATURE AT SET POINT (ADJUSTABLE).

MODES OF OPERATION: FAN COIL MODE OF OPERATION IS EITHER "OCCUPIED", "STANDBY", OR "UNOCCUPIED": OCCUPIED AND UNOCCUPIED MODES ARE DETERMINED BASED ON A CALENDAR AND TIME OF DAY SCHEDULE. STANDBY MODE IS DETERMINED DURING THE OCCUPIED MODE WITH INPUT FROM OCCUPANCY SENSOR. UNOCCUPIED MODE CAN BE OVERRIDDEN TO OCCUPIED MODE BY EITHER BUTTON AT THERMOSTAT FOR 2 HOURS (ADJUSTABLE) OR BY OCCUPANCY SENSOR.


STANDBY MODE: WHEN A SPACE MOTION DETECTOR IS PRESENT AND SENSES OCCUPANCY, MODE OF OPERATION SHALL BE "OCCUPIED" IF SENSOR DOES NOT SENSE OCCUPANCY, THEN SPACE WILL BE IN STANDBY MODE. DURING THE "STANDBY" MODE OF OPERATION, THE SET POINT SHALL BE ADJUSTED THROUGH THE DDC CONTROL PANEL BETWEEN A MINIMUM OF 71 DEG. F AND MAXIMUM OF 75 DEG. F. THERE SHALL BE A 3 DEG. F. DEAD BAND ON EITHER SIDE OF THE SETPOINT.

SEQUENCE OF OPERATION


### System Description

#### MODES OF OPERATION

**AIRE TERMINAL MODE OF OPERATION IS EITHER "OCCUPIED", \"STANDBY\", OR \"UNOCCUPIED\":**

- **OCCUPIED AND UNOCCUPIED MODES ARE DETERMINED BASED ON A CALENDARTIME OF DAY SCHEDULE. STANDARD MODE IS DETERMINED DURING THE OCCUPIED MODE WITH INPUT FROM OCCUPANCY SENSORS. UNOCCUPIED MODE CAN BE OVERRIDDEN TO OCCUPIED MODE BY EITHER BUTTON AT THERMOSTAT FOR 2 HOURS (ADJUSTABLE) OR BY OCCUPANCY SENSOR. THE TERMINAL FAN SHALL RUN CONTINUOUSLY.**

- **DAMPER POSITION MODULATES OPEN FROM MINIMUM POSITION TO MAXIMUM POSITION. ON A DECREASE IN SPACE TEMPERATURE BELOW SETPOINT, DAMPER CLOSES TO MINIMUM AND THE HEATING VALVE MODULATES TO MAINTAIN SETPOINT.**


**STANDBY MODE:**


**UNOCCUPIED MODE:**


### I/O Point Matrix

<table>
<thead>
<tr>
<th>I/O Point Matrix</th>
<th>Analog</th>
<th>Digital</th>
<th>Tracking</th>
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<td>Input Device</td>
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<tr>
<td>Motion Sensor</td>
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### Sequence of Operation

**MODES OF OPERATION:**

- **AIR TERMINAL MODE OF OPERATION IS EITHER \"OCCUPIED\", \"STANDBY\", OR \"UNOCCUPIED\":**

- **OCCUPIED AND UNOCCUPIED MODES ARE DETERMINED BASED ON A CALENDARTIME OF DAY SCHEDULE. STANDARD MODE IS DETERMINED DURING THE OCCUPIED MODE WITH INPUT FROM OCCUPANCY SENSORS. UNOCCUPIED MODE CAN BE OVERRIDDEN TO OCCUPIED MODE BY EITHER BUTTON AT THERMOSTAT FOR 2 HOURS (ADJUSTABLE) OR BY OCCUPANCY SENSOR. THE TERMINAL FAN SHALL RUN CONTINUOUSLY.**

- **DAMPER POSITION MODULATES OPEN FROM MINIMUM POSITION TO MAXIMUM POSITION. ON A DECREASE IN SPACE TEMPERATURE BELOW SETPOINT, DAMPER CLOSES TO MINIMUM AND THE HEATING VALVE MODULATES TO MAINTAIN SETPOINT.**


**STANDBY MODE:**


**UNOCCUPIED MODE:**

SYSTEM / DESCRIPTION

MODES OF OPERATION

AIR TERMINAL UNIT - DUAL DUCT

INPUT DEVICE

- UNOCCUPIED
- OCCUPIED
- STANDBY
- TEMPORARY OVERRIDE

OUTPUT DEVICE

- HOT DECK DAMPER
- COLD DECK DAMPER
- SUPPLY AIR
- DISCHARGE

SEQUENCE OF OPERATION

MODES OF OPERATION

- OCCUPIED
- STANDBY
- TEMPORARY OVERRIDE

TEMPERATURE SENSORS

- ZONE TEMPERATURE
- MOTION SENSOR
SEQUENCE OF OPERATION:

MODES OF OPERATION: AIR TERMINAL MODE OF OPERATION IS EITHER "OCCUPIED", "STANDBY", OR "UNOCCUPIED": OCCUPIED AND UNOCCUPIED MODES ARE DETERMINED BASED ON CALENDAR AND TIME OF DAY SCHEDULE. STANDBY MODE IS DETERMINED DURING THE OCCUPIED MODE WITH INPUT FROM OCCUPANCY SENSOR. UNOCCUPIED MODE CAN BE OVERRIDDEN TO OCCUPIED MODE BY EITHER BUTTON AT THERMOSTAT FOR 2 HOURS (ADJUSTABLE) OR BY OCCUPANCY SENSOR. AT COOLING SETPOINT, UNIT SHALL DELIVER MINIMUM COOLING CFM. ON AN INCREASE IN ROOM TEMPERATURE, TERMINAL DAMPER SHALL MODULATE UNTIL AT MAXIMUM FLOW. ON A DECREASE IN COOLING AIRFLOW APPROACHING COOLING SETPOINT, WITH DAMPER AT MINIMUM POSITION, UNIT FAN IS ENERGIZED TO PROVIDE PLENUM AIR TO THE SPACE AND HOT WATER VALVE MODULATES TO MAINTAIN SETPOINT.


STANDBY MODE: WHEN A SPACE MOTION DETECTOR IS PRESENT AND SENSES OCCUPANCY, MODE OF OPERATION SHALL BE "OCCUPIED." IF SENSOR DOES NOT SENSE OCCUPANCY, THEN SPACE WILL BE IN STANDBY MODE. DURING THE "STANDBY" MODE OF OPERATION, THE SET POINT SHALL BE ADJUSTED THROUGH THE DDC CONTROL PANEL BETWEEN A MINIMUM OF 71 DEG. F AND MAXIMUM OF 75 DEG. F. THERE SHALL BE A 3 DEG. F. DEAD BAND ON EITHER SIDE OF THE SETPOINT.

Air Terminal Unit Hot Water - Series Fan Powered

**Sequence of Operation**

**Modes of Operation:**

- **Air Terminal Mode of Operation:** is either "Occupied," "Standby," or "Unoccupied." Occupied and unoccupied modes are determined based on a calendar and time of day schedule. Standby mode is determined during the occupied mode with input from occupancy sensor. Unoccupied mode can be overridden to occupied mode by either button at thermostat for 2 hours (adjustable). On a rise in space temperature, damper position modulates open from minimum position to maximum position. On a decrease in space temperature below setpoint, damper closes to minimum and the heating valve modulates to maintain setpoint.

- **Occupied Mode:** during the "Occupied" mode of operation, the set point shall be adjusted through the DDC control panel between a minimum of 71 deg. F and maximum of 75 deg. F. There shall be a 3 deg. F dead band on either side of the setpoint.

- **Standby Mode:** when a space motion detector is present and senses occupancy, mode of operation shall be "Occupied." If sensor does not sense occupancy, then space will be in standby mode. During the "Standby" mode of operation, the set point shall be adjusted through the DDC control panel between a minimum of 71 deg. F and maximum of 75 deg. F. There shall be a 6 deg. F dead band on either side of the setpoint.

- **Unoccupied Mode:** during the "Unoccupied" mode of operation, the set point shall be adjusted through the DDC control panel between a minimum of 71 deg. F and maximum of 75 deg. F. There shall be a 6 deg. F dead band on either side of the setpoint.
**SEQUENCE OF OPERATION:**

**CHILL WATER CONTROL VALVE:** Chilled water control valve shall modulate as required to main space temperature setpoint (adj.).

**MODES OF OPERATION**
- **OCCUPIED** or **STANDBY** or **UNOCCUPIED**
  - **OCCUPIED AND UNOCCUPIED MODES** are determined based on a calendar and time of day schedule. Standby mode is determined during the occupied mode with input from auxiliary-sensing sensor. Unoccupied mode can be overridden to occupied mode by either button at thermostat for 2 hours (adjustable) or by occupancy sensor.
  - **OCCUPIED MODE:** During the "OCCUPIED" mode of operation, the set point shall be adjusted through the DDC control panel between a minimum of 71 deg. F and maximum of 75 deg. F. There shall be a 1 deg. F dead band on either side of the setpoint.
  - **STANDBY MODE:** When a space motion detector is present and senses occupancy, mode of operation shall be "OCCUPIED". If sensor does not sense occupancy, then space will be in STANDBY mode. During the STANDBY mode of operation, the set point shall be adjusted through the DDC control panel between a minimum of 71 deg. F and maximum of 75 deg. F. There shall be a 3 deg. F dead band on either side of the setpoint.
  - **UNOCCUPIED MODE:** During the "UNOCCUPIED" mode of operation, the set point shall be adjusted through the DDC control panel between a minimum of 71 deg. F and maximum of 75 deg. F. There shall be a 6 deg. F dead band on either side of the setpoint.

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**SYSTEM / DESCRIPTION**

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<tr>
<th>Analog Input</th>
<th>Digital Input</th>
<th>Analog Output</th>
<th>Digital Output</th>
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**I/O COUNT**

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**SYSTEM DRAWINGS**

1/6/2012 9:15:58 AM --- CB-COOL

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**DRAWING NAME:** CHILLED BEAM - COOLING ONLY

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**RFP - ATC IDIQ**

**STANDARD SYSTEM DRAWINGS**

---

**CHILLED BEAM - COOLING ONLY**

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**CB-COOL**
SEQUENCE OF OPERATION:
HOT WATER CONTROL VALVE SHALL MODULATE TO MAINTAIN SPACE TEMPERATURE SETPOINT. PROVIDE REMOTE ZONE SETPOINT (ADJ.).
### LAB AREA CONTROLS

**UNLESS SPECIFICALLY SHOWN OTHERWISE ON MECHANICAL ENGINEERING DRAWINGS, TEMPERATURE, HUMIDITY, PRESSURIZATION, AND FUME HOOD CONTROLS FOR LABORATORY AREAS SHALL BE PROVIDED BY LABORATORY HVAC AND CONTROL SYSTEM VENDOR. SUPPLY, GENERAL EXHAUST, AND FUME EXHAUST AIR TERMINALS ARE PROVIDED BY LABORATORY HVAC AND CONTROL SYSTEM VENDOR.**

**ATC SYSTEM VENDOR SHALL PROVIDE INTERFACE WITH LABORATORY HVAC AND CONTROL SYSTEM VENDORS SYSTEM AND MONITOR OPERATION AND ALARM POINTS AS INDICATED.**

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<tr>
<th>SYSTEM / DESCRIPTION</th>
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<th>DIGITAL</th>
<th>P</th>
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<td>ROOM ALARM</td>
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</table>

**LABORATORY AREA CONTROLS:**
SEQUENCE OF OPERATION:

EXHAUST FAN SHALL BE STARTED AND STOPPED BY THE DDC CONTROLLER. THE MOTORIZED DAMPER SHALL OPEN, AND WHEN OPEN ITS INTERNAL END SWITCH SHALL START THE EXHAUST FAN.

THE EXHAUST FAN SHALL BE STARTED AND OPERATED WHENEVER ITS ASSOCIATED AIR HANDLING UNIT IS IN OPERATIONAL. EXHAUST FAN SHALL NOT BE OPERATED UNLESS AT LEAST ONE ASSOCIATED AIR HANDLING UNIT IS IN OPERATION.
<table>
<thead>
<tr>
<th>Detail No.</th>
<th>Description</th>
<th>Diagram</th>
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</thead>
<tbody>
<tr>
<td>DX3</td>
<td>TEMPERATURE SENSOR</td>
<td><img src="dx3.png" alt="Diagram" /></td>
</tr>
<tr>
<td>DX6</td>
<td>ANALOG INPUT</td>
<td><img src="dx6.png" alt="Diagram" /></td>
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<tr>
<td>DX7</td>
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<td>DX22</td>
<td>BINARY OUTPUT</td>
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<tr>
<td>DX51</td>
<td>24VAC BINARY INPUT</td>
<td><img src="dx51.png" alt="Diagram" /></td>
</tr>
<tr>
<td>DX70</td>
<td>N.O. BINARY INPUT</td>
<td><img src="dx70.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>

**Notes:**
- If shielded cable is used, see DETAIL A-SHIELD-GROUND for shield termination.
- If shielded cable is used, see DETAIL DX-TERM or LCP-TERM for analog input jumper settings.
- Note: See DETAIL DX-TERM or LCP-TERM for analog output jumper settings.
- Field device must be terminated to 24VAC common.
- See DETAIL DX-TERM for shield termination.

**References:**
- DX3: TEMPERATURE SENSOR ANALOG INPUT
- DX6: 0-10VDC ANALOG INPUT EXTERNAL SOURCE
- DX7: 0-10VDC ANALOG INPUT INTERNAL SOURCE
- DX22: 0-10VDC ANALOG OUTPUT
- DX51: 24VAC BINARY OUTPUT
- DX70: N.O. BINARY INPUT

**Design Title:**
Chilled Water Control Diagram

**Requestor:**
Automatic Temperature Controls

**Project Title:**
Request for Proposal

**University of Arkansas**
Fayetteville, Arkansas
CHILLED WATER SYSTEM:

MODE OF OPERATION AND MANUAL DECOUPLER VALVE:

MODE OF OPERATION WILL BE EITHER "PRESSURE CONTROL" OR TEMPERATURE CONTROL". THE MODE OF OPERATION WILL BE DETERMINED BY OPERATOR COMMAND. THE STANDARD MODE OF OPERATION WILL BE THE "PRESSURE CONTROL" MODE. THE MANUAL VALVE IN THE DECOUPLER WILL BE CLOSED IN THE "PRESSURE CONTROL" MODE. IF THE MODE OF OPERATION IS CHANGED TO "TEMPERATURE CONTROL", THE MANUAL VALVE IN THE DECOUPLER MUST BE OPENED.

BUILDING COOLING:

BUILDING COOLING WILL BE ENABLED AND DISABLED BY THE METASYS ENERGY MANAGEMENT SYSTEM (EMS) BASED UPON WEEKLY SCHEDULE OR OPERATOR COMMAND.

CHILLED WATER VOLUMETRIC AND REFRIGERATION METERING:

THE METASYS EMS WILL CALCULATE AND RECORD THE AVERAGE CHILLED WATER VOLUMETRIC FLOW IN GPM FOR EACH 15 MINUTE TIME PERIOD. THE METASYS EMS WILL ALSO TOTALIZE AND RECORD THE CHILLED WATER FLOW IN 1,000 GALLONS (SUM OF THE 15 MINUTE AVERAGE FLOWS MULTIPLIED BY 60 AND DIVIDED BY 4,000).


CHILLED WATER PUMP:


"TEMPERATURE CONTROL" MODE - WHEN BUILDING COOLING IS DISABLED, THE CHILLED WATER PUMP WILL BE OFF. WHEN BUILDING COOLING IS ENABLED, THE CHILLED WATER PUMP WILL BE STARTED AND OPERATED. MAXIMUM OF 100% (ADJ.) AS REQUIRED TO MAINTAIN THE REMOTE CHILLED WATER DIFFERENTIAL PRESSURE AT SETPOINT OF 7 PSIG (ADJ.).

BUILDING CHILLED WATER CONTROL VALVE:

"PRESSURE CONTROL" MODE- WHEN BUILDING COOLING IS DISABLED, BUILDING CHILLED WATER CONTROL VALVE WILL BE CLOSED. WHEN BUILDING COOLING IS ENABLED AND THE CHILLED WATER PUMP IS IN OPERATION, THE BUILDING CHILLED WATER CONTROL VALVE WILL BE FULLY OPEN. WHEN BUILDING COOLING IS ENABLED AND THE CHILLED WATER PUMP IS NOT IN OPERATION, THE BUILDING CHILLED WATER VALVE WILL BE MODULATED AS REQUIRED TO MAINTAIN THE REMOTE CHILLED WATER DIFFERENTIAL PRESSURE AT SETPOINT OF 7 PSIG (ADJ.). WHEN THE BUILDING CHILLED WATER PUMP IS NOT IN OPERATION, THE BUILDING CHILLED WATER VALVE WILL BE OVERRIDDEN AS REQUIRED TO PREVENT THE CHILLED WATER FLOW RATE FROM EXCEEDING THE BUILDING MAXIMUM FLOW (SEPARATELY ADJ. FOR EACH BUILDING).

"TEMPERATURE CONTROL" MODE- WHEN BUILDING COOLING IS DISABLED, BUILDING CHILLED WATER CONTROL VALVE WILL BE CLOSED. WHEN BUILDING COOLING IS ENABLED, THE BUILDING CHILLED WATER CONTROL VALVE WILL BE MODULATED AS REQUIRED TO MAINTAIN THE CHILLED WATER RETURN TEMPERATURE AT SEPOINT OF 52 DEG. F. (ADJ.). VALVE CONTROL WILL BE OVERRIDDEN AS REQUIRED TO PREVENT THE CHILLED WATER FLOW RATE FROM EXCEEDING THE BUILDING MAXIMUM FLOW (SEPARATELY ADJ. FOR EACH BUILDING).

PRIMARY DIFFERENTIAL PRESSURE:

THE PRIMARY DIFFERENTIAL PRESSURE TRANSMITTER, LOCATED UPSTREAM OF THE BUILDING SHUTOFF VALVES, WILL PROVIDE A SIGNAL TO THE CAMPUS NETWORK TO CONTROL THE SPEED OF PRIMARY CHILLED WATER PUMPS (LOCATED IN VARIOUS CENTRAL PLANTS ON CAMPUS). THESE PRIMARY CHILLED WATER PUMPS WILL PROVIDE THE "SERVICE" PRESSURE DESCRIBED ABOVE.
Steam and Heating Water System

High and low steam pressures are monitored by the Metasys DDC panel. Relief valve operation is monitored by the Metasys DDC panel through a temperature sensor on the relief piping.

HOT WATER PUMP 1 VFD DETAIL

START/STOP
STATUS
SPEED CONTROL
ALARM STATUS

HOT WATER PUMP 2 VFD DETAIL

START/STOP
STATUS
SPEED CONTROL
ALARM STATUS

Wiring Legend

Pneumatic Tubing
Wire
Cable
Wired by JO
Wired by other
Wired by JCI

Wiring Legend

Pneumatic Tubing
Wire
Cable
Wired by JO
Wired by other
Wired by JCI

SEQUENCE OF OPERATIONS

STEAM AND HEATING WATER SYSTEM

High and low steam pressures are monitored by the Metasys DDC panel. Relief valve operation is monitored by the Metasys DDC panel through a temperature sensor on the relief piping.

HEATING WATER PUMP: The heating water pump will be started and stopped by the Metasys DDC panel based on a weekly schedule or operator command. The pumps are arranged in a lead/lag setup. If the lead pump fails, the lag pump will automatically start. Pumps will rotate lead status weekly. The pump speed will be controlled from the Metasys DDC panel through the variable frequency drive. The differential pressure transmitter, located 2/3 downstream from the pump, will via the Metasys DDC controller, maintain a differential pressure setpoint of 10 PSIG (Adj.).

TEMPERATURE CONTROL: Steam control valves are modulated in sequence by separate Metasys DDC analog outputs as required to maintain the heating water supply temperature at setpoint. Setpoint is 180 deg F (Adj.).

BILL OF MATERIALS

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<tr>
<th>Designation</th>
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Start/Stop Status

Temperature Control

Steam and Heating Water System

AFC-1, Detail 2

Automatic Temperature Controls - Request for Proposal

University of Arkansas
Fayetteville, Arkansas
### Drawing Title
Steam and Heating Water System

### System Title
ATC-1, Detail 2

### Project Name
Automatic Temperature Controls - Request for Proposal

### Project Location
University of Arkansas
Fayetteville, Arkansas

### Drawing Information

#### Drawing Number
DWG-02.01

#### Revision
4231-0015

#### Branch Information

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<th>Track Length</th>
<th>Notes</th>
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#### Notes:
- Note: See detail DX3 for field device, field device, and field device.
- Note: If shielded cable is used, see detail DX7 for shield termination.
- Note: If shielded cable is used, see detail DX2 for shield termination.
- Note: If shielded cable is used, see detail DX5 for shield termination.
- Note: If shielded cable is used, see detail DX7 for shield termination.

### Diagram

#### DETAIL DX3:
TEMPERATURE SENSOR ANALOG INPUT

#### DETAIL DX7:
9-VHVDC ANALOG INPUT INTERNAL SOURCE

#### DETAIL DX22:
9-VHVDC ANALOG OUTPUT

#### DETAIL DX5:
24-AC BINARY OUTPUT

#### DETAIL DX70:
N.O. BINARY INPUT
**BILL OF MATERIALS**

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<th>Designation</th>
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<td>DA-T,RA-T</td>
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</tr>
</tbody>
</table>

**SEQUENCE OF OPERATIONS**

**SUPPLY FAN**
- Supply fan is started and stopped by HOA switch at starter. When HOA switch is in the “hand” position, fan will start and stop by pushbuttons at the starter. When HOA switch is in the “auto” position, fan will be started and stopped by the METASYS DDC panel based upon a weekly occupied/unoccupied schedule. Fan will automatically stop by the fire alarm panel and low limit switch in the event of an unsafe condition.
- Supply fan is modulated by the METASYS DDC controller as required to maintain the space air temperature setpoint of 72 deg. F (adj.). Chilled water valve will automatically close whenever the supply fan is not in operation.
- Whenever the supply fan is in operation, the chilled water control valve will be modulated by the METASYS DDC controller as required to maintain the space air temperature setpoint of 72 deg. F (adj.). Heating water control valve will be modulated by the METASYS DDC controller as required to maintain space temperature setpoint of 70 deg. F (adj.). Heating water valve will be automatically closed whenever the supply fan is not in operation.
- Air dampers will modulate to provide outside air and maintain mixed air temperature. Dampers will be automatically closed whenever the supply fan is not in operation.
- Preheat control valve will modulate to maintain supply fan to preheat temperature.
<table>
<thead>
<tr>
<th>Field Metagraphics</th>
<th>Control Metagraphics</th>
<th>Field Metagraphics</th>
<th>Metagraphics Details</th>
<th>Field Notes</th>
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</thead>
<tbody>
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<td></td>
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</tbody>
</table>

**DETAIL D264**  
**0-10VDC OUTPUT to M-9216**

**DETAIL D301**  
**BINARY INPUT (DRY CONTACT)**

**DETAIL D302**  
**N.O. BINARY INPUT - A70**

---

**DETAIL D131**  
**TEMPERATURE SENSOR INPUT**

**DETAIL D502**  
**24 VAC BINARY OUTPUT to LOW CURRENT DRAW DEVICE** (Switch High)

**DETAIL DX3:**

**TEMPERATURE SENSOR ANALOG INPUT**

---

**NOTE:**
- Adjust R1, R2, and R3 for resistance (R1 and R2 for 0-10V, R3 for 0-20mA).
- The jumper is used to switch the Field Device between 0-10V and 0-20mA.
- The Field Device is supplied and installed as required.

---

**DETAIL DX:**

**TEMPERATURE SENSOR ANALOG INPUT**

---

**NOTE:**
- Adjust R1, R2, and R3 for resistance (R1 and R2 for 0-10V, R3 for 0-20mA).
- The jumper is used to switch the Field Device between 0-10V and 0-20mA.
- The Field Device is supplied and installed as required.
**Sequence of Operation:**

**Supply Fan:**
Supply fan will be started/stopped by HOA switch at VFD. When HOA switch is in the "Auto" position, fan will be started and stopped by pushbuttons at VFD, and fan speed will be controlled by manual potentiometer at VFD. When HOA switch is in the "Hand position, fan will be started and stopped by the Metasys DDC controller. Fan will be automatically started by fire alarm panel, low limit switch, door kill switch, and high static switch in the event of an unsafe condition. Supply fan speed will be modulated as required to maintain the supply duct static pressure at setpoint of 1.0 inches W.G. (Adj.).

**Chilled Water Control Valve:**
Whenever the supply fans are in operation, the chilled water control valve will modulate to maintain the chilled water valve at setpoint of 55 deg. F. (Adj.). Chilled water valve will be automatically closed whenever the supply fan is not in operation.

**Preheat Control Valve:**
Whenever the supply fans are in operation, the preheat control valve will modulate to maintain 50 deg. F. preheat temperature.
## Detail D131: Temperature Sensor Input

### 0-10VDC Output to M-9216

<table>
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<th>Component</th>
<th>Voltage Range</th>
<th>Notes</th>
</tr>
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<tbody>
<tr>
<td>VDC</td>
<td>0-10VDC</td>
<td>To Reverse the Spring Return Rotation, reverse the orientation of the Blade Pin Coupler.</td>
</tr>
</tbody>
</table>

### Field Device

- **Type**: BINARY INPUT (DRY CONTACT)
- **Location**: Field Device
- **Input Type**: Temperature Sensor
- **Output Type**: Analog Input

### Notes:
- **ANALOG INPUT**: Set the jumper to an externally powered source.
- **CALIBRATION**: Set the jumper to an external power source if required.
- **OUTPUT**: Set the jumper to an external power source if required.

## Detail D264: Temperature Sensor Input

### 0-10VDC Output to M-9216

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<thead>
<tr>
<th>Component</th>
<th>Voltage Range</th>
<th>Notes</th>
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<tr>
<td>VDC</td>
<td>0-10VDC</td>
<td>To Reverse the Spring Return Rotation, reverse the orientation of the Blade Pin Coupler.</td>
</tr>
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### Field Device

- **Type**: BINARY INPUT (DRY CONTACT)
- **Location**: Field Device
- **Input Type**: Temperature Sensor
- **Output Type**: Analog Input

### Notes:
- **ANALOG INPUT**: Set the jumper to an externally powered source.
- **CALIBRATION**: Set the jumper to an external power source if required.
- **OUTPUT**: Set the jumper to an external power source if required.

## Detail D301: Binary Input (Dry Contact)

### Field Device

- **Type**: BINARY INPUT (DRY CONTACT)
- **Location**: Field Device
- **Input Type**: N.O. BINARY INPUT - A70

### Notes:
- **ANALOG INPUT**: Set the jumper to an externally powered source.
- **CALIBRATION**: Set the jumper to an external power source if required.
- **OUTPUT**: Set the jumper to an external power source if required.

## Detail D502: 24VAC Binary Output to Low Current Draw Device (Switch High)

### Field Device

- **Type**: BINARY OUTPUT
- **Location**: Field Device
- **Input Type**: N.O. BINARY INPUT - A70
- **Output Type**: 24VAC

### Notes:
- **ANALOG INPUT**: Set the jumper to an externally powered source.
- **CALIBRATION**: Set the jumper to an external power source if required.
- **OUTPUT**: Set the jumper to an external power source if required.

## Detail DX3: Temperature Sensor Analog Input

### Field Device

- **Type**: BINARY INPUT (DRY CONTACT)
- **Location**: Field Device
- **Input Type**: Temperature Sensor
- **Output Type**: Analog Input

### Notes:
- **ANALOG INPUT**: Set the jumper to an externally powered source.
- **CALIBRATION**: Set the jumper to an external power source if required.
- **OUTPUT**: Set the jumper to an external power source if required.

## Detail DX6: 0-10VDC Analog Input External Source

### Field Device

- **Type**: BINARY INPUT (DRY CONTACT)
- **Location**: Field Device
- **Input Type**: Temperature Sensor
- **Output Type**: Analog Input

### Notes:
- **ANALOG INPUT**: Set the jumper to an externally powered source.
- **CALIBRATION**: Set the jumper to an external power source if required.
- **OUTPUT**: Set the jumper to an external power source if required.
**Sequence of operation**

**Supply and Exhaust Fans**
Fans will be started and stopped through the hand-off-auto control panel. When the switch is in the “auto” position, fans will be started and stopped by the DDC system based on weekly schedule or operator command. Fans will be automatically stopped by the supply high static switch, low limit switch, exhaust high static switch or fire alarm panel in the event of an unsafe condition. The outside air damper (furnished with the unit) is opened when the supply is on a prewired control circuits. An electric pneumatic solenoid valve will de-energize when the supply fan is off, closing the chilled water valve and the humidifier valve.

**Energy Wheel**
Energy wheel will be started and stopped by the hand-off-auto switch at the frequency drive. When the switch is in the “hand” position, the wheel will be started and stopped by pushbuttons located at the VFD. The wheel speed will be controlled by a potentiometer at the VFD. When the switch is in the “auto” position, the wheel will be started and stopped by the DDC system based on outside air temperature. The wheel will be stopped by the DDC system whenever the outside air temperature is above 85 degrees F (adjustable) and whenever the inside air temperature is below 50 degrees F (adjustable). When the outside air temperature is above 80 degrees F (summer mode), the wheel will be operated at full speed (60 HZ output power) by the DDC system analog output. When the outside air temperature is below 50 degrees F, the wheel speed will be modulated by the DDC panel as required to prevent the Energy Recovery Temperature from increasing above 50 degrees F (economizer function) and to prevent the exhaust air leaving temperature from decreasing below 35 degrees F (frost control). The energy wheel will be automatically stopped whenever the supply fan or the exhaust fan are not operating as indicated by current switches.

**Preheat steam control valve**
The preheat steam control valve will be modulated by the DDC system analog output through a pressure transducer as required to maintain the preheat steam supply air temperature at 180 degrees F (adjustable). The preheat steam control valve will be automatically open by an electric pneumatic solenoid valve whenever the supply fan is stopped.

**Chilled Water valve**
The chilled water valve will be modulated by the DDC system analog output through a pressure transducer as required to maintain the chilled water supply temperature at 40 degrees F (adjustable). A humidity high limit will override the signal to the valve to prevent the supply air humidity from exceeding 90% RH. The chilled water valve will be automatically closed by an electric pneumatic solenoid whenever the supply fan is stopped.

**Humidifier**
The humidifier steam valve will be modulated by the DDC system analog output through a pressure transducer as required to maintain the exhaust air entering humidity at 40% RH (adjustable). A humidity high limit will override the signal to the valve to prevent the supply air humidity from exceeding 90% RH. The humidifier steam valve will be automatically closed by an electric pneumatic solenoid whenever the supply fan is stopped.
<table>
<thead>
<tr>
<th>Control Information</th>
<th>Microfilm Signatures</th>
<th>Drawing Signatures</th>
<th>Drawing Title</th>
<th>Project Title</th>
<th>Reference Drawing</th>
<th>DWG-05.01</th>
<th>No. Rev.</th>
<th>Location</th>
<th>Contract No.</th>
<th>ATC-2, Detail 5</th>
<th>Academy</th>
<th>Comment</th>
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<tbody>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Detail DX3:**

**Temperature Sensor Analog Input**

**Detail DX7:**

8-VDC Analog Input Internal Source

**Detail DX2:**

8-VDC Analog Output

**Detail DX5:**

24-V DC Binary Output

**Detail DX7:**

N.O. Binary Input

**Detail DX7:**

N.C. Binary Input

---

**REFERENCE DRAWING**

Energy Recovery Air Handling Unit

Systems & Services Division

Johnson Controls Inc.

1226 North Garland Ave.

Fayetteville, AR 72701

Phone: 479-443-0571

Fax: 479-443-0580

---

**TABLE:**

**Location:** University of Arkansas

Fayetteville, Arkansas

---

**Drawing Title:** Automatic Temperature Controls - Request for Proposal

DWG-05.01

---

**NOTE:** See DETAIL DX21 for ANALOG INPUT JUMPER SETTINGS.

---

**NOTE:** See DETAIL DX22 for ANALOG OUTPUT JUMPER SETTINGS.

---

**NOTE:** See DETAIL DX71 for N.C. BINARY INPUT JUMPER SETTINGS.
**FAN COIL UNIT**

**FCU FAN WIRING DETAIL**

**BILLOF MATERIALS**

<table>
<thead>
<tr>
<th>Designation</th>
<th>Qty</th>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Devices:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DA-T</td>
<td>1</td>
<td>TE-6311P-1</td>
<td>SENSOR,T-IN,0.1%,8IN DUCT</td>
</tr>
<tr>
<td>DC-1</td>
<td>1</td>
<td>AS-VV/111-1</td>
<td>CONTROLLER,VAV,4A,48V,660-240V,BK</td>
</tr>
<tr>
<td>FCU-S</td>
<td>1</td>
<td>H-938</td>
<td>5KW CURR,2A-15SA,OMNI RLY SPLIT</td>
</tr>
<tr>
<td>Panel Devices:</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>DC-1</td>
<td>1</td>
<td>TE-67NP-4660</td>
<td>SENSOR,ROOM,110,PHONE JACK,W/C</td>
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<tr>
<td>Other Devices:</td>
<td></td>
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<tr>
<td>CWS</td>
<td>1</td>
<td>AS-ENC100-0</td>
<td>GEN ,ASC,ENC,6.875,250.0</td>
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<tr>
<td>CLG-VLV</td>
<td>1</td>
<td>VG3493A4-44600GA</td>
<td>1/2&quot; FPT 3/4&quot; RLY,SPLIT</td>
</tr>
<tr>
<td>HTG-VLV</td>
<td>1</td>
<td>VG3493A4-49000GA</td>
<td>1/2&quot; FPT 3/4&quot; RLY,SPLIT</td>
</tr>
</tbody>
</table>

**NOTES:**

(1) CONTROLLER SHALL HAVE THE ABILITY TO START/STOP AND MONITOR STATUS OF THREE (3) ADDITIONAL MECHANICAL DEVICES (3-DI & 3-DO) AND MONITOR FOUR (4) ADDITIONAL ANALOG INPUTS (4-AI) WITHOUT ADDING ANY ADDITIONAL CONTROLLER HARDWARE.

**SEQUENCE OF OPERATION**

**COOLING MODE:**

WHEN THE SPACE SENSOR INCREASES TWO DEGREES ABOVE SET POINT, THE CONTROLLER SHALL BE COMMANDED TO THE COOLING MODE. THE CHILLED WATER VALVE SHALL MODULATE TO MAINTAIN 55 DEGREES CONSTANT DISCHARGE TEMPERATURE. THE THREE SPEED FAN SHALL BE SEQUENCED OFF THROUGH LOW, MED, AND HIGH SPEEDS TO MAINTAIN SPACE TEMPERATURE SET POINT. HEATING VALVE SHALL BE CLOSED.

**HEATING MODE:**

WHEN THE SPACE SENSOR DECREASES TWO DEGREES BELOW SET POINT, THE CONTROLLER SHALL BE COMMANDED TO THE HEATING MODE. THE FAN SHALL BE COMMANDED ON AND THE HEATING WATER VALVE SHALL BE MODULATED TO MAINTAIN SPACE TEMPERATURE AT SET POINT. THE SPEED OF THE FAN SHALL BE SELECTED FROM THE EMS SYSTEM. COOLING VALVE SHALL BE CLOSED.
**Temperature Sensor Analog Input**

**DETAIL UV1:**

**0-10V DC Analog Output**

**DETAIL UV23:**

**24VAC Binary Output**

**DETAIL UV51:**

**N.O. Binary Input**

**DETAIL UV70:**

- **ANALOG INPUT**
- **SEE TERMINAL BOARD LAYOUT DETAIL FOR JUMPER SETTINGS.**
- **DEVICE**
- **FIELD**
- **-**
- **+**
- **CN O**
- **TO 24VAC IF SWITCH LOW**
- **TO 24VAC IF SWITCH HIGH**
- **TO 24VAC IF SWITCH OPEN**
- **TO 24VAC IF SWITCH CLOSED**
- **NOT CHARTED FORWARD TO 24VAC IF SWITCH LOW**
- **NOT CHARTED FORWARD TO 24VAC IF SWITCH HIGH**
- **NOT CHARTED FORWARD TO 24VAC IF SWITCH OPEN**
- **NOT CHARTED FORWARD TO 24VAC IF SWITCH CLOSED**
**SEQUENCE OF OPERATION**

**Fan Status**

- SF-S: NO

**System Name**

- Located: All Devices Terminated at Division Unless Otherwise Noted

**Rooftop or Packaged Unit Enclosure**

**Supply Fan Start/Stop**

The supply fan will be started automatically according to the schedule for the occupied command set by the FMS operator. If the supply fan status (SF-S) does not match the commanded value within 30 sec (adjustable), an alarm will be sent to the operator workstation. When the status is sensed, the unit’s occupied control sequence will begin.

**Zone Temperature Control**

The air handling unit will be controlled to maintain the space temperature setpoint of 72°F (adjustable) as sensed by the room thermostat (ZN-T).

**DX Cooling Control (Space)**

The DX cooling will cycle to maintain the space temperature setpoint.

**Electric Reheat Coil Control (Space)**

The electric (or gas) heating stages will cycle to maintain the space temperature setpoint.

**Night Setback/Night Setup**

When in "Unoccupied" mode, the unit cycles on and off as necessary to maintain the night setback room temperature setpoints of 60°F (adjustable) heating or 82°F (adjustable) cooling. A 5°F differential prevents the unit from cycling excessively.

**Shutdown**

When the unit is shutdown by either a stop command or system safety, the unit will be set as follows:

- DX cooling will be off
- Electric (or gas) heat will be off

---

**T-Stat Controller Wiring Details**

Run an 8 cond 18GA cable using the colors shown and leaving the remaining two wires as spare.

---

**Bill of Materials**

<table>
<thead>
<tr>
<th>Designation</th>
<th>Qty</th>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Devices</td>
<td>DA-T</td>
<td>1</td>
<td>SEN-600-3 O.A TEMP COMBI MOD FTSE DUCT</td>
</tr>
<tr>
<td>SF-S</td>
<td>1</td>
<td>H-803</td>
<td>3 WIRE CURRENT 2.5/30A GO/NO SOLID</td>
</tr>
<tr>
<td>TSTAT</td>
<td>1</td>
<td>TEC1103-1</td>
<td>TSTAT W/2 HEAT/2 COOL</td>
</tr>
</tbody>
</table>

---

**Drawing Title**

Split System with 2 Stage Htg/Clg

ATC-2, Detail 7

---

**Application**

Automatic Temperature Controls - Request for Proposal

University of Arkansas

---

**Contact Information**

Johnson Controls, Inc.

1960 Legler Road

Lenexa, KS 66219

Phone: (913) 307-4200

Fax: (913) 492-1167

RS 12/30/2002

---

**Group/Title**

DWG-07.00

4231-0015
SINGLE DUCT VAV WITH INCREMENTAL HOT WATER REHEAT

Field Mounted Transformer
Factory Mounted Controls
Discharge Air from Air Handling Unit

VMA CONTROLLER WIRING DETAILS

Wiring Legend:
- Preconfigured 24-pin patch cable w/ RJ-45 connectors
- 18/3 N3 Communications Bus: See Communications Riser Drawing
- 18/3 Twisted Cable
- 18/2 Twisted Cable
- 18/3 Cable or (2) 18/2 Cables

Notes:
- General: See Room Schedule for box locations, addresses, slaving, and MAX and MIN CFM values.
- See Mechanical drawings for room thermostat locations.

Bill of Materials

<table>
<thead>
<tr>
<th>Designation</th>
<th>Qty</th>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Devices:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CABLE</td>
<td>1</td>
<td>CBL-ST/TM100</td>
<td>METASTAT CBL, RJ45 100 FT EA</td>
</tr>
<tr>
<td>DA-T</td>
<td>1</td>
<td>TE-GG1/1-1</td>
<td>SENSOR, TEMP IN, N1, 4 PROBE, DUCT MNT</td>
</tr>
<tr>
<td>HTG-GLY</td>
<td>1</td>
<td>VGADHTGLY350</td>
<td>UP VP PROBE, CV 3-550 C, FLOATING, SHAD</td>
</tr>
<tr>
<td>VMA</td>
<td>1</td>
<td>AP-VMA-02E-0</td>
<td>VOL MLI UAR-ASY - CLG W/ REHEAT</td>
</tr>
<tr>
<td>XFR</td>
<td>1</td>
<td>VSG-02-0</td>
<td>XFER (120/375, 40VA) (2) 6005</td>
</tr>
<tr>
<td>ZN-T</td>
<td>1</td>
<td>AP-TXMT216-0</td>
<td>ROOM SENSOR WL/CD DISPLAY</td>
</tr>
</tbody>
</table>

Sequence of Operation

Occupied Mode:
When the room temperature is between the heating and cooling set points, the VAV controller sets the box at minimum CFM and fully closes the reheat valve. On a rise in room temperature above the cooling setpoint, the VAV controller modulates the box damper to increase the CFM. The reheat valve remains fully closed. On a drop in room temperature below the heating setpoint, the VAV controller modulates the reheat valve and controls the damper at minimum CFM.

Warm-Up Mode:
When the air handling unit starts in warm-up mode, all VAV controllers are indexed to warm-up mode. The VAV controller modulates the box damper to maintain the occupied heating temperature setpoint, and the reheat valve is disabled (the air handling unit will be discharging 85 deg F). At the completion of warm-up mode, the individual VAV controllers are indexed to either occupied or shutdown mode, depending on the status of the air-handling unit.

Shutdown Mode:
When the AHU shuts down, all of the Metasys DDC box controllers are indexed to shutdown mode whereby the box dampers and reheat valves are fully closed.
YorkTalk Translator/XL Applications

YorkTalk Translator/XL

YORKTALK TRANSLATOR/XL PROVIDED AND PROGRAMMED BY YORK

YORKTALK TRANSLATOR/XL APPLICATIONS

YorkTalk Translator Setup for York Controllers

- Metasys Integrator Setup
- 300 Series, 2-Port Integrator
- 20X24X9 PERF-SUB W/ DOOR
- 4 IN S/S COVER W/ RECEP/SW/FUSE BOX
- 120V AC W/ GROUND

Bill of Materials

<table>
<thead>
<tr>
<th>Designation</th>
<th>Qty</th>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformer</td>
<td>1</td>
<td>120/24V W/ GROUND</td>
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</tr>
</tbody>
</table>

Table 2: Metasys Integrator Setup for York Controllers

<table>
<thead>
<tr>
<th>Panel Device</th>
<th>Qty</th>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTEGRATOR</td>
<td>1</td>
<td>1169010002</td>
<td>Metasys Integrator, 200 Series, 2-Port</td>
</tr>
<tr>
<td>PANEL-HH</td>
<td>1</td>
<td>6266568651</td>
<td>Panel, Hoffman 20X24X9 PERF-SUB W/ DOOR</td>
</tr>
<tr>
<td>PD-117-9</td>
<td>1</td>
<td>8642532286</td>
<td>4 IN S/S COVER W/ RECEP/SW/FUSE BOX</td>
</tr>
<tr>
<td>PD-117-9</td>
<td>1</td>
<td>4694336326</td>
<td>120V AC W/ GROUND</td>
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</tbody>
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Table 8: LS 1000-1250 Ton Rotary Screw Chiller

<table>
<thead>
<tr>
<th>NPT</th>
<th>NPTA</th>
<th>Unit</th>
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<tr>
<td>A1</td>
<td>1</td>
<td>DegF</td>
</tr>
<tr>
<td>A2</td>
<td>2</td>
<td>DegF</td>
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<tr>
<td>A3</td>
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<td>DegF</td>
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<td>A4</td>
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<td>A6</td>
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<td>A7</td>
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<td>A11</td>
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<td>A12</td>
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<td>A13</td>
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<td>%</td>
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<td>A14</td>
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<td>DegF</td>
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<tr>
<td>A15</td>
<td>15</td>
<td>%</td>
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Table 8 Continued:

<table>
<thead>
<tr>
<th>Description</th>
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<tbody>
<tr>
<td>Chiller Interface Diagram</td>
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<tr>
<td>York LS 1000-1250 Ton Rotary Screw Chiller</td>
</tr>
<tr>
<td>ATC-2, Detail 9</td>
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</table>

Project Title: Automatic Temperature Controls - Request for Proposal

University of Arkansas
Fayetteville, Arkansas

4231-0015
11/1/1999

Dwg 09-01

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TRANE BCU APPLICATIONS

TRANE INTEGRATION SETUP

Table 1: Metasys Integrator Setup for BCU

<table>
<thead>
<tr>
<th>Vendor Communication Table (VCT) File</th>
</tr>
</thead>
<tbody>
<tr>
<td>See Example in VCT file for this application note</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BCU with Trane Sunsoft Software</th>
<th>Version 6.0 or higher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Template: G6 (device reserves 25 points on the BCU network)</td>
<td></td>
</tr>
<tr>
<td>Universal Template: (Each device reserves 10, 20, 30, or 40 points in a BCU network. Each device is assigned only one VCT file, which contains one to four 10-point templates)</td>
<td></td>
</tr>
<tr>
<td>A device with up to 10 points requires one template.</td>
<td></td>
</tr>
<tr>
<td>A device with up to 15 points requires two templates.</td>
<td></td>
</tr>
<tr>
<td>A device with up to 20 to 30 points requires three templates.</td>
<td></td>
</tr>
<tr>
<td>A device with up to 31 to 40 points requires four templates.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Part Setup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baud Rate</td>
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<tr>
<td>Word Length</td>
</tr>
<tr>
<td>Stop Bit</td>
</tr>
<tr>
<td>Parity</td>
</tr>
<tr>
<td>Interface</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Network Setup (G6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vendor Address: XXYYZZZZZ,</td>
</tr>
<tr>
<td>where XX = the destination network ID where the BCU resides (see box 01 for TT)</td>
</tr>
<tr>
<td>YY = the destination BCU device ID (see box 03 for TT)</td>
</tr>
<tr>
<td>ZZ = the decimal number of the first (initial) template assigned to a device (see the Using Universal Templates and Standard Template sections of this application note)</td>
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<table>
<thead>
<tr>
<th>Timeover Value</th>
<th>0.010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poll Delay: Chiller and Aux. Units (BCU)</td>
<td>0 ms</td>
</tr>
<tr>
<td>Performance Guide</td>
<td>0.5 ms</td>
</tr>
<tr>
<td>Approximate Scan Time</td>
<td>1 second</td>
</tr>
</tbody>
</table>

Table 10: Example - Using Three Universal Templates to Configure an Air-cooled RTAA Chiller (TR-051010.VCT)

<table>
<thead>
<tr>
<th>Template</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>TR_V05BU.VCT</td>
<td>Trane RTAA Air-Cooled Chiller</td>
</tr>
<tr>
<td>TR_V05BU.VCT</td>
<td>Automatic Temperature Controls - Request for Proposal</td>
</tr>
<tr>
<td>TR_V05BU.VCT</td>
<td>BILL OF MATERIALS</td>
</tr>
</tbody>
</table>

Panel Devices: | INTEGRATOR |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>MS-845120-0</td>
<td>NETASYS INTEGRATOR, 200 SERIES 2-PORT</td>
</tr>
<tr>
<td>PAN-EN21024HDP</td>
<td>PANEL, HOFFMAN 20X24X36 PERF SUB W/ DOOR</td>
</tr>
<tr>
<td>IG-115-6</td>
<td>20X36 COVER W/ RECESSION/FUSE BOX</td>
</tr>
<tr>
<td>9Y4110-0</td>
<td>XFM1-120-260-24V/24V 629A, F/B, 30% LEADS</td>
</tr>
</tbody>
</table>

References: | | |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Johnson Controls Inc.</td>
<td>Fayetteville, Arkansas</td>
</tr>
<tr>
<td></td>
<td>4231-0015</td>
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<td></td>
<td>DWG-09.02</td>
</tr>
</tbody>
</table>
HONEYWELL Q7700 APPLICATIONS

Q7700 INTEGRATION SETUP

Table 1: Metasys Integrator Setup for Honeywell Burner and Boiler Controls

<table>
<thead>
<tr>
<th>Vendor Communication Table (VCT) File</th>
<th>BCS 7700 Boiler Control System</th>
<th>7800 SERIES Burner Control</th>
<th>S/330 Expanded Annunciator</th>
</tr>
</thead>
</table>

Port Setup
- Baud Rate: 9600
- Word Length: 8
- Stop Bits: 1
- Parity: None
- Interface: RS-485

Network Setup
- Vendor Address: 101

Q7700 COMMUNICATIONS INTERFACE

Table 3: 7800 SERIES Burner Control Points

<table>
<thead>
<tr>
<th>Slot</th>
<th>1 Volt</th>
<th>Flame Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Test Run Switch</td>
<td>0-volt, 1 volt</td>
</tr>
<tr>
<td>2</td>
<td>Operating Control</td>
<td>0-volt, 1 volt</td>
</tr>
<tr>
<td>3</td>
<td>Interlock</td>
<td>0-volt, 1 volt</td>
</tr>
<tr>
<td>4</td>
<td>Pilot Valve</td>
<td>0-volt, 1 volt</td>
</tr>
<tr>
<td>5</td>
<td>Main Valve</td>
<td>0-volt, 1 volt</td>
</tr>
<tr>
<td>6</td>
<td>Ignition</td>
<td>0-volt, 1 volt</td>
</tr>
<tr>
<td>7</td>
<td>Pilot Valve Hold</td>
<td>0-volt, 1 volt</td>
</tr>
<tr>
<td>8</td>
<td>Manual Open Switch</td>
<td>0-volt, 1 volt</td>
</tr>
<tr>
<td>9</td>
<td>Low Fire Switch</td>
<td>0-volt, 1 volt</td>
</tr>
<tr>
<td>10</td>
<td>High Fire Switch</td>
<td>0-volt, 1 volt</td>
</tr>
<tr>
<td>11</td>
<td>Pre-Ignition Switch</td>
<td>0-volt, 1 volt</td>
</tr>
<tr>
<td>12</td>
<td>Valve 2 Start</td>
<td>0-volt, 1 volt</td>
</tr>
</tbody>
</table>

Table of Materials

<table>
<thead>
<tr>
<th>Designation</th>
<th>Qty</th>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MM-CVT101-0</td>
<td>1</td>
<td>N2 CONVERTER RS-232/RS-485, PC VERSION</td>
<td></td>
</tr>
<tr>
<td>MS-MIG3120-0</td>
<td>1</td>
<td>METASYS INTEGRATOR, 300 SERIES, 2-PORT</td>
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Designation: HONEYWELL Q7700 APPLICATIONS

At the request of Johnson Controls, Inc.

For the automated temperature controls - request for proposal

University of Arkansas

Fayetteville, Arkansas

Bill of Materials

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</table>
**SUPPLY AND EXHAUST BOX FOR LAB CONTROL**

---

**SEQUENCE OF OPERATION:**

**FUME HOOD CONTROL - PROVIDED OUTSIDE OF THIS PROPOSAL:**

The fume hood exhaust damper is modulated by the fume hood velocity controller as required to maintain the face velocity at setpoint (adjusted at the fume hood controller).

**SUPPLY AIR TERMINAL CONTROL:**

The supply damper is modulated by the Metasys DDC controller as required to maintain the supply air flow at setpoint (adj.). When the lights in the lab are on as indicated by the lighting circuit sensor, the "occupied" air flow setpoint (approximately 12 changes per hour) will be used. When the lights in the lab are off as indicated by the lighting circuit sensor and the fume hood sash is closed as indicated by a fume hood exhaust air flow less than 350 CFM (adj.), the "unoccupied" air flow setpoint (approximately 4 changes per hour) will be used. The heating water control valve is modulated as required to maintain the room temperature setpoint.

**EXHAUST AIR TERMINAL CONTROL:**

The terminal damper is modulated by the Metasys DDC controller as required to maintain the difference between the sum of the exhaust air flows and the supply air flow at 100 CFM (laboratory is maintained at a negative pressure relationship to the corridor).

---

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<td>DPT-2015-1</td>
<td>0-15mV DPT Press to Electric Transp</td>
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<td>120SM-FDF-74500</td>
<td>1/2&quot; SW PTC/SHT 2 HC FLOATING, 24VAC</td>
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**Bill of Materials**

- Field Devices:
  - Box-DPR, EXH-DPR: M9104-AGS-ZN (Act Float 30W R 80Sec DPT 2015 Sensor)
  - TV-VP: DPT-2015-1 (0-15mV DPT Press to Electric Transp)
  - HTG-VLV: 120SM-FDF-74500 (1/2" SW PTC/SHT 2 HC Floating, 24VAC)
  - ODC-S: HTB1100 (SW CURRENT 1/2" ADJ (APPEAR SPLIT CORE))
  - SA-T: TE-631GV-1 (SENSOR TEMP 1/10K, 4 PI PROBE, DUCT MNT)
  - ZN-T: AP-N71600-9 (ROOM SENSOR W/DC DISPLAY)

- Panel Devices:
  - DC-1: AS-ENC160-0 (GENER ASC ENC/6X 8X7 24VAC)

**Fume Hood System Flow Diagram**

- Sequence of Operation:
  - Fume Hood Control: Provided outside of this proposal.
  - Supply Air Terminal Control: The supply damper is modulated by the Metasys DDC controller as required to maintain the supply air flow at setpoint (adj.).
  - Exhaust Air Terminal Control: The terminal damper is modulated by the Metasys DDC controller as required to maintain the difference between the sum of the exhaust air flows and the supply air flow at 100 CFM (laboratory is maintained at a negative pressure relationship to the corridor).

**Fume Hood Wiring Diagram**

- Supplied by others. Not part of this work. Shown for informational purposes only.
### Diagram Description

#### Temperature Sensor Analog Input

**Diagram Elements**
- **METASTAT Input**
- **Analog Input**

**Details**
- **Device**: Field
- **Point**: 0-10VDC Analog Input Internal Source

#### Detail UV1

**Diagram Elements**
- **Temperature Sensor Analog Input**
- **Analog Input**

**Details**
- **Point**: 0-10VDC Analog Input Internal Source

#### Detail UV2

**Diagram Elements**
- **Temperature Sensor Analog Input**
- **Analog Input**

**Details**
- **Point**: 0-10VDC Analog Input Internal Source

#### Detail UV5

**Diagram Elements**
- **Temperature Sensor Analog Input**
- **Analog Input**

**Details**
- **Point**: 0-10VDC Analog Input Internal Source

#### Detail UV54

**Diagram Elements**
- **Temperature Sensor Analog Input**
- **Analog Input**

**Details**
- **Point**: 0-10VDC Analog Input Internal Source

#### Detail UV59

**Diagram Elements**
- **Temperature Sensor Analog Input**
- **Analog Input**

**Details**
- **Point**: 0-10VDC Analog Input Internal Source

#### Detail UV70

**Diagram Elements**
- **Temperature Sensor Analog Input**
- **Analog Input**

**Details**
- **Point**: 0-10VDC Analog Input Internal Source
Factory Wiring

Field Wiring

RJ45

18/2

18/3

Preconfigured 24/8 patch cable w/ RJ-45 connectors.

18/3 N2 Communications Bus.

See Communications Riser Drawing.

18/2 Twisted Cable.

18/3 Twisted Cable.

Wiring Legend:

[18H] 18/4 Cable or (2) 18/2 Cables.

[18N] 18/3 Twisted Cable.

Factory Mounted Controls

Discharge Air from Air Handling Unit

Differential Pressure Transmitter mounted integral with DMPR

CONTROL WIRING TO RESPECTIVE SUPPLY AIR TERMINAL CONTROLLER

CONTROL TUBING TO RESPECTIVE SUPPLY AIR TERMINAL CONTROLLER

THE METASYS DDC CONTROLLER WILL MODULATE THE TERMINAL DAMPER AS REQUIRED TO MAINTAIN THE EXHAUST AIR FLOW AT SETPOINT. THE SETPOINT WILL BE EQUAL TO THE SUPPLY AIR FLOW RATE TO THE AREA SERVED LESS THE OFFSET. THE OFFSET WILL BE 0 CFM FOR THE NEUTRAL PRESSURE RELATIONSHIP (OFFICES) AND 100 CFM PER DOOR FOR NEGATIVE PRESSURE RELATIONSHIP (TOILETS AND LABORATORY SUPPORT AREAS).
**Single Duct VAV with Incremental Hot Water Reheat**

**Factory Mounted Controls**

**Field Mounted Transformer**
- Factory Mounted Controls
- Field Mounted Controls
- Discharge Air from Air Handling Unit

**VMA Controller Wiring Details**

**Sequence of Operation**
- The controller will modulate the terminal damper as required to maintain the air flow at setpoint (constant volume).
- The controller will modulate the heating water control valve as required to maintain the space temperature at setpoint of 72 deg. F (adj.).

**Bill of Materials**

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**Notes:**
- General:
  - See Room Schedule for box locations, addresses, and VAV and MIN CFM values.
  - See Mechanical drawings for room thermostat locations.

**Wiring Legend:**
- Preconfigured 24p patch cable w/ RA-10 connectors
- 18/3 N2 Communications Bus. See Communications Riser Drawing.
- 18/2 N2 Communication Bus
- Factory Wiring
- Field Wiring

---

**Diagram Title:** Corridor Supply Air Control

**Drawing Title:** Automatic Temperature Controls - Request for Proposal

**Project Title:** University of Arkansas
SINGLE DUCT VAV WITH INCREMENTAL HOT WATER REHEAT

Field Mounted Transformer
- MOUNTED ON DUCT INFILL
- PD-WAVMTR - 4 BOXES
- T8VA - 4 BOXES
- T8VA - 3 BOXES
- 44VA - 2 BOXES

Factory Mounted Controls
- DA-T
- HTG-VLV
- VM
- XFR
- TN-Z

Discharge Air from Air Handling Unit

VMA CONTROLLER WIRING DETAILS

Wiring Legend:
- Preconfigured 24V patch cable w/ RJ-45 connectors
- 164 Cable or (2) 162 Cables
- Factory Wiring
- Field Wiring

Notes:
- Cable coverage
- See Room Schedule for box locations, addresses, wiring, and MAX CFM values
- See Mechanical drawings for room thermostat locations

Designation Qty Part Number Description
Field Devices:
- CABLE 1 CB-001A1000-METASTAT CB 850 SHFT EA
- CT 1 1H3B
- DA-T 1 TEC-Q02-1 SENSOR, TEMP IN/OUT, I/O PROBE, DUCT SHFT
- HTG-VLV 1 VG37F0C07400 12' LOW-VOLT SHFT, 120-240V
- VM 1 VM-001A-000 18/2, 18/3 SW1/W15 BAT
- XFR 1 VM-001A-000 14/4 SW1/W15 BAT
- ZN-T 1 TN-Z0010000500000 ROOM SENSOR W/LCD DISPLAY

BILLOFMATERIALS

Designation Quantity Part Number Description
Field Devices:
- CABLE 1 CBL-STAT100 METASTAT CBL RJ45 100FT EA
- CT 1 H608 SW,CURRENT,1-50A,ADJ,MINI,SPLIT CORE,LED
- DA-T 1 TE-Q02V-1 SENSOR,TEMP IN/OUT, I/O PROBE, DUCT SHFT
- HTG-VLV 1 VG37F0C07400 12' LOW-VOLT SHFT, 120-240V
- VM 1 VM-001A-000 18/2, 18/3 SW1/W15 BAT
- XFR 1 VM-001A-000 14/4 SW1/W15 BAT
- ZN-T 1 TN-Z0010000500000 ROOM SENSOR W/LCD DISPLAY

General:
- See Room Schedule for box locations, addresses, slaving, and MAX and MIN CFM values
- See Mechanical drawings for room thermostat locations

Notes:
- Disch Temp
- DA-T 2/18
- Red Black
- HWR
- HTG-VLV
- HWS
- H C
- ZN-T
- WC-ADJ
- Factory Mounted Controls
- Single Duct VAV with Incremental Hot Water Reheat

Sequenced of Operation

Air Terminal Mode of operation is either "occupied" or "unoccupied" based upon status of room lighting. "Occupied" when lights are "on" and "unoccupied" when lights are "off". The Metasys controller will modulate the terminal damper and the heating water control valve as required to maintain the space temperature at setpoint.

During the "occupied" mode of operation, the setpoint will be adjustable by the occupant at the thermostat between a minimum of 68 deg. F. and maximum of 75 deg. F. On a call for cooling, the terminal damper will be modulated between the cooling minimum and the cooling maximum air flow rates scheduled. On a call for heating, the terminal damper will be modulated between the heating minimum and the maximum air flow rates scheduled. During the "unoccupied" mode of operation, the heating setpoint will be 80 deg. F. and the cooling setpoint will be 60 deg. F. On a call for cooling, the terminal damper will be modulated from fully closed (0 CFM) to the maximum cooling air flow rate scheduled. On a call for heating, the terminal damper will be modulated from fully closed (0 CFM) to the maximum heating air flow rate scheduled.
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**Sequence of Operation:**

UNIT HEATER FAN AND HEATING WATER CONTROL VALVE ARE SEQUENCED BY THE METASYS DDC CONTROLLER AS REQUIRED TO MAINTAIN THE SPACE TEMPERATURE AT SETPOINT.

**Sequence of Operation:**

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**Sequence of Operation:**

UNIT HEATER FAN AND HEATING WATER CONTROL VALVE ARE SEQUENCED BY THE METASYS DDC CONTROLLER AS REQUIRED TO MAINTAIN THE SPACE TEMPERATURE AT SETPOINT.
**DETAIL UV2:**

**METASTAT**

**INPUT**

**METASTAT**

**PHONE JACK INTO CONTROLLER**

**CABLE ATTACHMENT CONNECTOR FOR ENGAGEMENT**

**DETAIL UV51:**

**24VAC TRIAC OUTPUT TO VA-8020**

**FIELD DEVICE**

**DETAIL UV70:**

**N.O. BINARY INPUT**

**FIELD DEVICE**

**DETAIL UV15:**

**24VAC BINARY OUTPUT**

**FIELD DEVICE**

**DETAIL UV58:**

**24VAC TRIAC OUTPUT TO VA-8020**

**FIELD DEVICE**

**NOTE:**

**SEE TERMINAL BOARD LAYOUT DETAIL FOR JUMPER SETTINGS.**

**METASTAT**

**INPUT**

**METASTAT**

**PHONE JACK INTO CONTROLLER**

**CABLE ATTACHMENT CONNECTOR FOR ENGAGEMENT**

**DETAIL UV51:**

**24VAC TRIAC OUTPUT TO VA-8020**

**FIELD DEVICE**

**DETAIL UV70:**

**N.O. BINARY INPUT**

**FIELD DEVICE**

**DETAIL UV15:**

**24VAC BINARY OUTPUT**

**FIELD DEVICE**

**DETAIL UV58:**

**24VAC TRIAC OUTPUT TO VA-8020**

**FIELD DEVICE**

**NOTE:**

**SEE TERMINAL BOARD LAYOUT DETAIL FOR JUMPER SETTINGS.**

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**INPUT**

**METASTAT**

**PHONE JACK INTO CONTROLLER**

**CABLE ATTACHMENT CONNECTOR FOR ENGAGEMENT**

**DETAIL UV51:**

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**FIELD DEVICE**

**DETAIL UV58:**

**24VAC TRIAC OUTPUT TO VA-8020**

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**NOTE:**

**SEE TERMINAL BOARD LAYOUT DETAIL FOR JUMPER SETTINGS.**

**METASTAT**

**INPUT**

**METASTAT**

**PHONE JACK INTO CONTROLLER**

**CABLE ATTACHMENT CONNECTOR FOR ENGAGEMENT**

**DETAIL UV51:**

**24VAC TRIAC OUTPUT TO VA-8020**

**FIELD DEVICE**

**DETAIL UV70:**

**N.O. BINARY INPUT**

**FIELD DEVICE**

**DETAIL UV15:**

**24VAC BINARY OUTPUT**

**FIELD DEVICE**

**DETAIL UV58:**

**24VAC TRIAC OUTPUT TO VA-8020**

**FIELD DEVICE**

**NOTE:**

**SEE TERMINAL BOARD LAYOUT DETAIL FOR JUMPER SETTINGS.**

**METASTAT**

**INPUT**

**METASTAT**

**PHONE JACK INTO CONTROLLER**

**CABLE ATTACHMENT CONNECTOR FOR ENGAGEMENT**

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**NOTE:**

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**FIELD DEVICE**

**DETAIL UV58:**

**24VAC TRIAC OUTPUT TO VA-8020**

**FIELD DEVICE**

**NOTE:**

**SEE TERMINAL BOARD LAYOUT DETAIL FOR JUMPER SETTINGS.**
BILL OF MATERIALS

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SEQUENCE OF OPERATION:

HUMIDIFIER STEAM CONTROL VALVES:

HUMIDIFIER STEAM CONTROL VALVE WILL BE MODULATED BY THE METASYS DDC CONTROLLER THROUGH PRESSURE TRANSDUCER AND ANALOG OUTPUT AS REQUIRED TO MAINTAIN THE RETURN AIR RELATIVE HUMIDITY AT SETPOINT OF 35% RH. HUMIDIFIER STEAM CONTROL VALVE WILL BE CLOSED WHENEVER A SUPPLY FAN IS NOT IN OPERATION.
SEQUENCE OF OPERATION:

BUILDING STEAM USAGE IS MEASURED BY AN ORIFICE PLATE FLOW METER AND A DIFFERENTIAL PRESSURE AND TRANSMITTER WITH INTEGRAL SQUARE ROOT EXTRACTOR. BUILDING STEAM FLOW IS TOTALIZED. BUILDING LOW PRESSURE STEAM USAGE CAN BE SHUT OFF BY OPERATOR THROUGH METASYS DDC CONTROLLER BY ELECTRIC PILOTS AT THE PRESSURE REDUCING VALVES. STEAM PRESSURE IS MONITORED BY THE METASYS DDC CONTROLLER. RELIEF VALVE OPERATION IS MONITORED BY THE METASYS DDC CONTROLLER THROUGH A STRAP-ON TEMPERATURE SENSOR ON THE RELIEF PIPING.
TEMPERATURE SENSOR

ANALOG INPUT

DETAIL UV1:

DETAIL UV5:

8-48VDC ANALOG INPUT INTERNAL SOURCE

24VAC BINARY OUTPUT

DETAIL UV51:
SEQUENCE OF OPERATION:

EXHAUST FAN WILL BE STARTED AND STOPPED BY SEPARATE METASYS DDC CONTROLLER DIGITAL OUTPUTS. EXHAUST FAN WILL BE STARTED AND OPERATED WHENEVER ASSOCIATED AIR HANDLING UNITS ARE IN OPERATION. EXHAUST FAN WILL NOT BE OPERATED UNLESS AT LEAST ONE ASSOCIATED AIR HANDLING UNIT IS IN OPERATION. MOTORIZED DAMPER WILL OPEN ON FAN STARTUP AND CLOSE ON FAN SHUTDOWN.

BILL OF MATERIALS

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Panel Devices:

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Wiring Legend:

- Pneumatic Tubing
- Wired by IC
- Wired by other
- Power
### Exhaust Fan Control Diagram

#### Point Metadata

| Point | Sensor/Motor | Output Relay | Expanded ID | Controller Type | Controller Device | Tray + Way | Total Data | Color | Description | Raw Terminal | Device | Transmission | Location | Wiring | Transmitter | Reference | Cable | Notes | Notes | Notes
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#### Controller Metadata

- **Controller Type**: UVN
- **Controller Device**: 209
- **Tray + Way**: 1 10
- **Total Data**: 0
- **Color**: 20
- **Description**: 50
- **Raw Terminal**: 0
- **Device**: 0
- **Transmission**: 0
- **Location**: 0
- **Wiring**: 0
- **Transmitter**: 0
- **Reference**: 0
- **Cable**: 0
- **Notes**: 0

#### Field Metadata

- **Field Device**: 20
- **Field Input**: 20

---

**Detail UV51:**

24VAC Binary Output

- **Field Device**: H
- **N**: 20
- **55**: 35

**Detail UV70:**

N.O. Binary Input

- **Field Device**: 20
- **Input**: 35
1.6 DUCT CONSTRUCTION AND INSTALLATION STANDARDS

S1.0 General Requirements

S1.1 These construction and installation specifications and illustrations include:
   a) single-prescription method requirements,
   b) optional alternatives, and
   c) performance requirements for specific items that are different in detail from the generalized illustrations.

S1.2 These standards are not meant to exclude any products or methods that can be demonstrated to be equivalent in performance for the application. Substitutions based on sponsor demonstrated adequacy and approval of the regulating authority are recognized.

S1.3 These requirements presume that the designers have prepared contract drawings showing the size and location of ductwork, including permissible fitting configurations. Where area change, direction change, divided flow, or united flow fittings other than those illustrated are shown on the contract drawings, are not of proprietary manufacture, and are defined with friction loss coefficients in either the SMACNA HVAC Duct System Design manual or the ASHRAE Fundamentals Handbook chapter on duct design, such fittings shall be fabricated with materials, assembly techniques, and sealing provisions given here.

S1.4 EACH DUCT SYSTEM SHALL BE CONSTRUCTED FOR THE SPECIFIC DUCT PRESSURE CLASSIFICATIONS SHOWN ON THE CONTRACT DRAWINGS. WHERE NO PRESSURE CLASSES ARE SPECIFIED BY THE DESIGNER, THE 1" WATER GAGE (250 Pa) PRESSURE CLASS IS THE BASIS OF COMPLIANCE WITH THESE STANDARDS, REGARDLESS OF VELOCITY IN THE DUCT, EXCEPT WHEN THE DUCT IS VARIABLE VOLUME: ALL VARIABLE VOLUME DUCT UPSTREAM OF VAV BOXES HAS A 2" W.G. (500 Pa) BASIS OF COMPLIANCE WHEN THE DESIGNER DOES NOT GIVE A PRESSURE CLASS.

S1.5 No specification or illustration in this manual obliges a contractor to supply any volume control dampers, fire dampers, smoke dampers, or fittings that are not shown on contract drawings.

S1.6 Where dimensions, sizes, and arrangements of elements of duct assembly and support systems are not provided in these standards the contractor shall select configurations suitable for the service.

S1.7 The contractor shall follow the application recommendations of the manufacturer of all hardware and accessory items and select them to be consistent with the duct classification and services.

S1.8 Unless otherwise specified steel sheet and strip used for duct and connectors shall be G-60 coated galvanized steel of lockforming grade conforming to ASTM A653 and A924 standards. Minimum yield strength for steel sheet and reinforcements is 30,000 psi (207 kPa).

S1.9 Where sealing is required in Table 1-2 or in other tables or illustrations in this manual, it means the following:
   a) the use of adhesives, gaskets, tape systems, or combinations of these to close openings in the surface of the ductwork and field-erected plenums and casings through which air leakage would occur or the use of continuous welds.
   b) the prudent selection and application of sealing methods by fabricators and installers, giving due consideration to the designated pressure class, pressure mode (positive or negative), chemical compatibility of the closure system, potential movement of mating parts, workmanship, amount and type of handling, cleanliness of surfaces, product shelf life, curing time, and manufacturer-identified exposure limitations.
   c) that these provisions apply to duct connections to equipment and to apparatus but are not for equipment and apparatus.
   d) that where distinctions are made between seams and joints, a seam is defined as joining of two longitudinally (in the direction of airflow) oriented edges of...
### TABLE 1-2
STANDARD DUCT SEALING REQUIREMENTS

<table>
<thead>
<tr>
<th>SEAL CLASS</th>
<th>Sealing Requirements</th>
<th>Applicable Static Pressure Construction Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Class A: All Transverse joints, longitudinal seams, and duct wall penetrations</td>
<td>4&quot; w.g. and up (1000 Pa)</td>
</tr>
<tr>
<td>B</td>
<td>Class B: All Transverse joints and longitudinal seams only</td>
<td>3&quot; w.g. (750 Pa)</td>
</tr>
<tr>
<td>C</td>
<td>Class C: Transverse joints only</td>
<td>2&quot; w.g. (500 Pa)</td>
</tr>
</tbody>
</table>

In addition to the above, any variable air volume system duct of 1" (250 Pa) and 1/2" w.g. (125 Pa) construction class that is upstream of the VAV boxes shall meet Seal Class C.

duct surface material occurring between two joints. Helical (spiral) lock seams are exempt from sealant requirements. All other duct wall connections are deemed to be joints. Joints include but are not limited to girth joints, branch and subbranch intersections, so-called duct collartap-ins, fitting subsections, louver and air terminal connections to ducts, access door and access panel frames and jambs, and duct, plenum, and casing abutments to building structures.

e) unless otherwise specified by the designer, that sealing requirements do not contain provisions to:

1. resist chemical attack;
2. be dielectrically isolated;
3. be waterproof, weatherproof, or ultraviolet ray resistant;
4. withstand temperatures higher than 120°F (49°C) or lower than 40°F (4.4°C);
5. contain atomic radiation or serve in other safety-related construction;
6. be electrically grounded;
7. maintain leakage integrity at pressures in excess of their duct classification;
8. be underground below the watertable;
9. be submerged in liquid;
10. withstand continuous vibration visible to the naked eye;
11. be totally leakfree within an encapsulating vapor barrier; and
12. create closure in portions of the building structure used as ducts, such as ceiling plenums, shafts, or pressurized compartments;

f) the requirements to seal apply to both positive and negative pressure modes of operation;

g) externally insulated ducts located outside of buildings shall be sealed before being insulated, as though they were inside. If air leak sites in ducts located outside of buildings are exposed to weather, they shall receive exterior duct sealant. An exterior duct sealant is defined as a sealant that is marketed specifically as forming a positive air-and watertight seal, bonding well to the metal involved, remaining flexible with metal movement, and having a service temperature range of -30°F (-34°C) to 175°F (79°C). If exposed to direct sunlight, it shall also be ultraviolet ray-and ozone-resistant or shall, after curing, be painted with a compatible coating that provides such resistance. The term sealant is not limited to adhesives or mastics but includes tapes and combinations of open-weave fabric or absorbent strips and mastics.
1.7 DUCT SEALING COMMENTARY

Ducts must be sufficiently airtight to ensure economical and quiet performance of the system. It must be recognized that airtightness in ducts cannot, and need not, be absolute (as it must be in a water piping system). Codes normally require that ducts be reasonably airtight. Concerns for energy conservation, humidity control, space temperature control, room air movement, ventilation, maintenance, etc., necessitate regulating leakage by prescriptive measures in construction standards. Leakage is largely a function of static pressure and the amount of leakage in a system is significantly related to system size. Adequate airtightness can normally be ensured by a) selecting a static pressure, construction class suitable for the operating condition, and b) sealing the ductwork properly.

The designer is responsible for determining the pressure class or classes required for duct construction and for evaluating the amount of sealing necessary to achieve system performance objectives. It is recommended that all ducts constructed for the 1" (250 Pa) and 1/2" (125 Pa) pressure class meet Seal Class C. However, because designers sometimes deem leakage in unsealed ducts not to have adverse effects, the sealing of all ducts in the 1" (250 Pa) and 1/2" (125 Pa) pressure class is not required by this construction manual. Designers occasionally exempt the following from sealing requirements: small systems, residential occupancies, ducts located directly in the zones they serve, ducts that have short runs from volume control boxes to diffusers, certain return air ceiling plenum applications, etc. When Seal Class C is to apply to all 1" (250 Pa) and 1/2" (125 Pa) pressure class duct, the designer must require this in the project specification. The designer should review the HVAC Air Duct Leakage Test Manual for estimated and practical leakage allowances.

Seven pressure classes exist [1/2" (125 Pa), 1" (250 Pa), 2" (500 Pa), 3" (750 Pa), 4" (1000 Pa), 6" (1500 Pa) and 10" (2500 Pa) w.g.]. If the designer does not designate pressure class for duct construction on the contract drawings, the basis of compliance with the SMACNA HVAC Duct Construction Standards is as follows: 2" (500 Pa) w.g. for all ducts between the supply fan and variable volume control boxes and 1" (250 Pa) w.g. for all other ducts of any application.

Some sealants can adversely affect the release function of breakaway connections to fire dampers; consult the damper manufacturer for installation restrictions.

1.7.1 Leakage Tests

There is no need to verify leakage control by field testing when adequate methods of assembly and sealing are used. Leakage tests are an added expense in system installation. It is not recommended that duct systems constructed to 3" (750 Pa) w.g. class or lower be tested because this is generally not cost effective. For duct systems constructed to 4" (1000 Pa) w.g. class and higher, the designer must determine if any justification for testing exists. If it does, the contract documents must clearly designate the portions of the system(s) to be tested and the appropriate test methods. ASHRAE energy conservation standards series 90 text on leakage control generally requires tests only for pressures in excess of 3" (750 Pa).

The HVAC Duct Leakage Test Manual provides practical and detailed procedures for conducting leakage tests.

Apparent differences of about ten percent between fan delivery and sum of airflow measurements at terminals do not necessarily mean poor sealing and excess leakage. Potential accuracy of flow measurements should be evaluated.

Otherwise, open access doors, unmade connections, missing end caps, or other oversights contribute to such discrepancies. When air terminals are at great distances from fans (over 500 feet (152m)), more effective sealing is probably required to avoid diminished system performance.

Schools, shopping centers, airports, and other buildings may use exposed ductwork. Selecting sealing systems for such ducts may involve more attention to the final appearance of the duct system than with ducts in concealed spaces.

Certain types of paint may form reliable seals, particularly for small cracks and holes. Further research and confirmation is needed in this area.

Longstanding industry acceptance of so-called low pressure duct systems without sealants may have left some contractors (and designers) with little or no experience with sealing. The contractor should carefully select construction details consistent with sealing requirements, the direction of the air pressure, and familiar sealing methods. The cost of restoring systems not receiving the required sealing or not being properly sealed can greatly exceed the modest cost of a proper application. Contractors using slip and drive connection
systems must control connector length and notch depth on rectangular duct ends to facilitate sealing. Failure to do so will compromise seal effectiveness. Round duct joints are normally easier to seal than other types. However, with proper attention to joint selection, workmanship, and sealant application, almost any joint can achieve low leakage. The mere presence of sealant at a connection, however, does not ensure low leakage. Applying sealant in a spiral lockseam can result in poor seam closure and less satisfactory control. No single sealant is the best for all applications. Selecting the most appropriate sealant depends primarily on the basic joint design and on application conditions such as joint position, clearances, direction of air pressure in service, etc.

The listing of certain duct products by recognized test laboratories may be based on the use of a particular joint sealing product. Such a component listing only reflects laboratory test performance and does not necessarily mean that the closure method can routinely be successful for the contractor or that it will withstand in-service operation of the system on a long-term basis.

1.7.2 Liquids

Many manufacturers produce liquid sealants specifically for ducts. They have the consistency of heavy syrup and can be applied either by brush or with a cartridge gun or powered pump. Liquid sealants normally contain 30 to 60 percent volatile solvents; therefore, they shrink considerably when drying. They are not recommended for slip-type joints where the sealant fills a small space between the overlapping pieces of metal. Where metal clearances exceed 1/16 inch (1.6 mm), several applications may be necessary to fill the voids caused by shrinkage or runout of the sealant. These sealants are normally brushed on to round slip joints and pumped into rectangular slip joints.

1.7.3 Mastics

Heavy mastic sealants are more suitable as fillets, in grooves, or between flanges. Mastics must have excellent adhesion and elasticity. Although not marketed specifically for ductwork, high quality curtain wall sealants have been used for this application. Oil-base caulking and glazing compounds should not be used.

1.7.4 Gaskets

Durable materials such as soft elastomer butyl or extruded forms of sealants should be used in flanged joints. For ease of application, gaskets should have adhesive backing or otherwise be tacky enough to adhere to the metal during joint assembly. The choice of open cell or closed cell rubber gaskets depends on the amount and frequency of compression and on the elastic memory.

1.7.5 Tapes

Nothing in this standard is intended to unconditionally prohibit the use of pressure sensitive tapes. Several such closures are listed as components of systems complying with UL Standard 181 tests. There are no industry recognized performance standards that set forth peel adhesion, shear adhesion, tensile strength, temperature limits, accelerated aging, etc., which are quality control characteristics specifically correlated with metal duct construction service. However, the SMACNA Fibrous Glass Duct Construction Standards illustrate the closure of a fibrous duct to metal duct with a tape system. The variety of advertised products is very broad. Some test results for tapes are published in the product directories of the Pressure Sensitive Tape Council located in Chicago, IL.

The shelf life of tapes may be difficult to identify. It may be only six months or one year. Although initial adhesion may appear satisfactory, the aging characteristics of these tapes in service is questionable. They tend to lose adhesion progressively at edges or from exposures to air pressure, flexure, the drying effects at the holes or cracks being sealed, etc. The tape's adhesive may be chemically incompatible with the substrate, as is apparently the case with certain nonmetal flexible ducts. Application over uncured sealant may have failures related to the release of volatile solvents. Sea air may have different effects on rubber, acrylic, silicone-based (or other) adhesives.

Tapes of a gum-like consistency with one or two removable waxed liners have become popular for some applications. They are generally known as the peel and seal variety and have been used between flanges and on the exterior of ducts. Such tapes are typically of thicknesses several times that of tapes traditionally known as the pressure sensitive type. Some may have mesh reinforcement. Others may have metal or nonmetal backing on one surface.

1.7.6 Heat Applied Materials

Hot melt and thermally activated sealants are less widely known but are used for ductwork. The hot melt type is normally a shop application. Thermally activated types use heat to either shrink-fit closures or to expand compounds within joint systems.