AMENDMENT TO REQUEST FOR PROPOSALS
Air-Cooled Condensing System

REQUEST FOR PROPOSALS #15P0015MG
Procurement Officer: Michael Grahek
Issue Date: January 6, 2015

AMENDMENT NO. 5
Effective Date: July 6, 2015

ISSUED TO:
All Prospective Offerors

ISSUED BY:
University of Alaska Fairbanks
Procurement & Contract Services
PO Box 757940
Fairbanks AK 99775-7940

Dear Vendor:

The following clarifications, revisions, and changes have been made to Request for Proposals No. 15P0015MG for an Air-Cooled Condensing System:

CHANGE: The Submittal Deadline for proposals is hereby changed:

TO: JULY 31, 2015, 5:00PM, AKDT

REPLACE: Annex A – Technical Specifications with the attached Annex A (351 pages)

UAF has revised its specifications for the Air-Cooled Condensing System as this portion of its Combined Heat and Power Plant Project has been re-scoped.

All other terms and conditions remain the same.

Sincerely,

UNIVERSITY OF ALASKA FAIRBANKS

Michael Grahek, C.P.M.
Sr. Contracting Officer
Annex A - Technical Specifications

for

Request for Proposals No. 15P0015MG
Amendment No. 5 - July 6, 2015
Air-Cooled Condenser System

Combined Heat and Power Plant
Replacement Project
Project No. 2012031 CPHR

University of Alaska Fairbanks
Fairbanks, Alaska

Issued for Bid
January 2015

Revised 6/23/15
Annex A – Technical Specifications

for

Contract Number 3418
Air Cooled Condensing System

University of Alaska Fairbanks
Fairbanks, Alaska

June 8, 2015
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIVISION 00</td>
<td>PROCUREMENT AND CONTRACTING REQUIREMENTS</td>
</tr>
<tr>
<td>00 01 01</td>
<td>Title Page</td>
</tr>
<tr>
<td>00 01 07</td>
<td>Seal Sheet</td>
</tr>
<tr>
<td>00 01 10</td>
<td>Table of Contents (this document)</td>
</tr>
<tr>
<td>00 31 00</td>
<td>Available Project Information</td>
</tr>
<tr>
<td>DIVISION 01</td>
<td>GENERAL REQUIREMENTS</td>
</tr>
<tr>
<td>01 10 00</td>
<td>Summary</td>
</tr>
<tr>
<td>01 11 00</td>
<td>Summary of Work (Division of Responsibility)</td>
</tr>
<tr>
<td>01 18 00</td>
<td>Terminal Points</td>
</tr>
<tr>
<td>01 25 13</td>
<td>Product Substitution Procedures</td>
</tr>
<tr>
<td>01 30 00</td>
<td>Administrative Requirements</td>
</tr>
<tr>
<td>01 32 19</td>
<td>Submittals Schedule</td>
</tr>
<tr>
<td>01 33 00</td>
<td>Submittal Procedures</td>
</tr>
<tr>
<td>01 40 00</td>
<td>Quality Requirements</td>
</tr>
<tr>
<td>01 41 00</td>
<td>Regulatory Requirements</td>
</tr>
<tr>
<td>01 42 19</td>
<td>Reference Standards</td>
</tr>
<tr>
<td>01 43 30</td>
<td>Welding Qualifications</td>
</tr>
<tr>
<td>01 43 33</td>
<td>Manufacturer’s Field Services</td>
</tr>
<tr>
<td>01 43 39</td>
<td>Models</td>
</tr>
<tr>
<td>01 60 00</td>
<td>Product Requirements</td>
</tr>
<tr>
<td>01 63 00</td>
<td>Approved Subcontractors and Suppliers List</td>
</tr>
<tr>
<td>01 78 23</td>
<td>Operating and Maintenance</td>
</tr>
<tr>
<td>01 78 41</td>
<td>Special Tools</td>
</tr>
<tr>
<td>01 83 00</td>
<td>Structural Performance Requirements</td>
</tr>
<tr>
<td>01 86 37</td>
<td>Condensing System Performance Requirements</td>
</tr>
</tbody>
</table>

| DIVISION 05 | METALS |
| 05 10 00 | Structural Metal Framing |
| 05 21 00 | Steel Joists |
| 05 50 00 | Metal Fabrications |

| DIVISION 09 | FINISHES |
| 09 92 00 | Industrial Painting and Coating |

| DIVISION 26 | ELECTRICAL |
| 26 05 00 | Common Work Results for Electrical |
| 26 05 03 | Small and Medium 3-Phase Motors |
| 26 29 23 | Low Voltage Variable Frequency Drives |

| DIVISION 40 | PROCESS INTEGRATION |
| 40 01 50 | Nozzle Reaction Loads and Moments Requirements |
| 40 05 13 | Common Work Results for Process Piping |
| 40 05 23 | General Duty Valves and Accessories |
| 40 05 29 | Supports and Anchors for Process Piping and Equipment |
| 40 91 00 | Primary Process Measuring Devices |
| 40 95 13 | Process Control Panels and Hardware |
| 40 96 00 | Process Control Software |
TABLE OF CONTENTS

Page 2 - SECTION 3418.00 01 10

DIVISION 48  ELECTRICAL POWER GENERATION

48 11 16  Steam Surface Condenser
48 11 17  Air Cooled Condenser

EXHIBITS

Exhibit A  Conceptual Drawings – For Reference Only
Exhibit B  Geotechnical Report
PART 1  GENERAL

1.01 SITE CONDITIONS

A. Facility Location
   1. Existing Facility Address:
      a. 802 Alumni Drive, Fairbanks, Alaska 99775
   2. Approximately 3 miles northwest of Fairbanks International Airport on the campus of the University of
      Alaska - Fairbanks.
   3. Approximate Coordinates: 64° 51.235’N, 147° 49.155’W

B. Site Physical Conditions
   1. Elevation: MSL +437.8 feet
   2. Barometer, in. Hg. abs.: 29.4.
   3. Ambient Temperatures
      a. Extreme High: 93°F
      b. Extreme Low: -66°F
   4. Normal Rainfall: (5 Yr. Occurrence In 24 Hr. Period) 1.8”
   5. Maximum Rainfall: (100 Yr. Occurrence In 24 Hr. Period) 3.4”
   6. Mean Annual Snowfall: 67.1 Inches (Airport)

C. Environmental Design Conditions
   1. 0.4% Cooling Design Condition:
      a. Ambient Dry Bulb Temperature: 82°F
      b. Mean Coincident Wet Bulb Temperature: 62°F
   2. 0.4% Evaporation Design Condition:
      a. Wet Bulb Temperature: 63°F
      b. Mean Coincident Dry Bulb Temperature: 77°F
   3. 99.6% Heating Design Condition:
      a. Dry Bulb Temperature: -47°F
   4. Indoor Ambient Design Temperature:
      a. Dry Bulb Temperature: 115°F
   5. ASHRAE Extreme Wind Speeds
      a) 1% Wind: 18 MPH
      b) 2.5% Wind: 15 MPH
      c) 5% Wind: 13 MPH

D. Noise Limitations
   1. Equipment furnished shall meet the following noise criteria specified. The Seller shall provide
      silencers as required to meet these requirements.
   2. Near field noise requirement for equipment located inside the facility shall be guaranteed to be less
      than 85 dB at 3 feet horizontal distance from equipment and 5 feet above floor level.
   3. Equipment may exceed the 85 dB near field noise limit where required sound attenuation measures
      are deemed impractical by the Buyer. In these cases, signage shall be used to indicate that hearing
      protection is required in that area.
   4. The Seller shall make a good faith effort to design or purchase equipment that will meet the noise
      requirements with the minimum amount of acoustical insulation that is practical for the application.
   5. The Seller shall notify the Buyer of any Buyer supplied noise mitigation measures that will be
      necessary for each piece of equipment. This notification shall occur as soon as practical after the
      Seller becomes aware of the need for noise mitigation. The Seller need not notify the Buyer regarding
      insulation that would otherwise have been required for thermal reasons.
### E. Wind Rose and Statistics

![Wind Rose Diagram]

<table>
<thead>
<tr>
<th>Percent of Time</th>
<th>1.3 – 4 MPH</th>
<th>4-8 MPH</th>
<th>8-13 MPH</th>
<th>13 – 19 MPH</th>
<th>Total</th>
<th>Calm (&lt;1.3 MPH)</th>
<th>Ave Speed (MPH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>1.1%</td>
<td>0.7%</td>
<td>0.1%</td>
<td>0.0%</td>
<td>1.9%</td>
<td></td>
<td>8.8</td>
</tr>
<tr>
<td>NNE</td>
<td>1.3%</td>
<td>0.9%</td>
<td>0.1%</td>
<td>0.0%</td>
<td>2.2%</td>
<td></td>
<td>4.2</td>
</tr>
<tr>
<td>NE</td>
<td>1.6%</td>
<td>1.4%</td>
<td>0.2%</td>
<td>0.0%</td>
<td>3.3%</td>
<td></td>
<td>4.3</td>
</tr>
<tr>
<td>ENE</td>
<td>2.7%</td>
<td>2.6%</td>
<td>0.2%</td>
<td>0.0%</td>
<td>5.5%</td>
<td></td>
<td>4.1</td>
</tr>
<tr>
<td>E</td>
<td>2.9%</td>
<td>1.5%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>4.4%</td>
<td></td>
<td>3.7</td>
</tr>
<tr>
<td>ESE</td>
<td>1.3%</td>
<td>3.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>1.7%</td>
<td></td>
<td>3.9</td>
</tr>
<tr>
<td>SE</td>
<td>0.8%</td>
<td>3.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>1.2%</td>
<td></td>
<td>4.2</td>
</tr>
<tr>
<td>SSE</td>
<td>0.8%</td>
<td>4.0%</td>
<td>0.1%</td>
<td>0.0%</td>
<td>1.2%</td>
<td></td>
<td>4.4</td>
</tr>
<tr>
<td>S</td>
<td>3.1%</td>
<td>2.1%</td>
<td>0.6%</td>
<td>0.0%</td>
<td>5.8%</td>
<td></td>
<td>3.9</td>
</tr>
<tr>
<td>SSW</td>
<td>1.7%</td>
<td>1.0%</td>
<td>0.1%</td>
<td>0.0%</td>
<td>2.8%</td>
<td></td>
<td>4.2</td>
</tr>
<tr>
<td>SW</td>
<td>2.1%</td>
<td>1.0%</td>
<td>0.2%</td>
<td>0.0%</td>
<td>3.4%</td>
<td></td>
<td>4.7</td>
</tr>
<tr>
<td>WSW</td>
<td>1.7%</td>
<td>1.1%</td>
<td>0.4%</td>
<td>0.0%</td>
<td>3.3%</td>
<td></td>
<td>4.4</td>
</tr>
<tr>
<td>W</td>
<td>1.3%</td>
<td>0.8%</td>
<td>0.2%</td>
<td>0.0%</td>
<td>2.4%</td>
<td></td>
<td>3.7</td>
</tr>
<tr>
<td>WNW</td>
<td>0.7%</td>
<td>0.3%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>1.0%</td>
<td></td>
<td>3.7</td>
</tr>
<tr>
<td>NW</td>
<td>0.6%</td>
<td>0.3%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.9%</td>
<td></td>
<td>3.9</td>
</tr>
<tr>
<td>NNW</td>
<td>0.7%</td>
<td>0.4%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>1.2%</td>
<td></td>
<td>1.8</td>
</tr>
<tr>
<td>Total</td>
<td>24.4%</td>
<td>15.0%</td>
<td>2.3%</td>
<td>0.2%</td>
<td>42.0%</td>
<td></td>
<td>58.0%</td>
</tr>
</tbody>
</table>
F. Structural Design Criteria
   a. Reference Section 01 83 00 – Structural Performance Requirements for the following design
      criteria:
   b. Seismic
   c. Wind loads
   d. Snow loads
   e. Other design criteria not related to the local environment

G. Insulation Design Criteria
   1. Specify insulation for personnel protection or for thermal performance as required by Sellers
      design
   2. Specify insulation and heat tracing for exterior pipelines that are subject to freezing at extreme
      low ambient conditions
   3. Equipment and piping surface temperatures shall not exceed 140 deg. F, with the exception of
      the following:
      a. Surfaces that are out of reach of personnel at the point of closest access.
      b. Surfaces that are greater than 10 feet above the closest access.
      c. Expanded metal mesh may be utilized in lieu of insulation for personnel protection for
         surfaces that do not require insulation for thermal performance.

PART 2    PRODUCTS

        NOT USED

PART 3    EXECUTION

        NOT USED

        END OF SECTION

1) R. Hernandez
2)
Instructions for Data Tables:

a) Data sheets may require information not known until Seller’s engineering is complete. Furnish estimated values based on good engineering judgment. Estimated values shall be identified by placement of “(est.)” next to value.

b) Do not leave items blank or labeled “To Be Determined” or “Later.”

c) Include the term “(est.)” or similar for items that contain preliminary or estimated data.

d) Do not submit Seller Product Data instead of completed data sheets.

e) Provide a datasheet for each type of motor and each type of VFD being offered.

Instructions for Guarantee Sheets:

a) Bidder guarantees performance at the values which are entered in Guaranteed Performance Sheets Provided by Seller.

b) Bidder shall adhere to required operating conditions when provided in the Spec Data column. Bidders may provide predicted conditions that are below a stated maximum or above a stated minimum.

c) Conditions marked as “By Seller” in the Spec Data column have no specific performance requirement. The Bidder shall provide this information based on their predicted performance calculations.
### AIR COOLED CONDENSER DATASHEET

#### DESCRIPTION

<table>
<thead>
<tr>
<th>Units</th>
<th>SPEC DATA</th>
<th>VENDOR DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### GUARANTEE CONDITIONS (by Engineer)

<table>
<thead>
<tr>
<th>GUARANTEE CONDITIONS</th>
<th>°F</th>
<th>psia</th>
<th>in HgA</th>
<th>kpph</th>
<th>BTU/lb</th>
<th>°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ambient Air Dry Bulb Temperature</td>
<td>93</td>
<td>14.44</td>
<td>10.510</td>
<td>1,077</td>
<td>161.4</td>
<td></td>
</tr>
<tr>
<td>2. Barometric Pressure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Steam Turbine Exhaust Pressure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Steam Turbine Exhaust Mass Flowrate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Steam Turbine Exhaust Enthalpy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Steam Turbine Exhaust Temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Steam Turbine Exhaust Energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Site Elevation Above Sea Level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>437.8</td>
<td></td>
</tr>
<tr>
<td>9. Auxiliary Power Consumption*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>By Seller</td>
</tr>
</tbody>
</table>

### AIR COOLED CONDENSER DATASHEET

#### DESCRIPTION

<table>
<thead>
<tr>
<th>Units</th>
<th>SPEC DATA</th>
<th>VENDOR DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### GUARANTEE CONDITIONS (by Engineer)

<table>
<thead>
<tr>
<th>GUARANTEE CONDITIONS</th>
<th>°F</th>
<th>psia</th>
<th>in HgA</th>
<th>kpph</th>
<th>BTU/lb</th>
<th>°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ambient Air Dry Bulb Temperature</td>
<td>40</td>
<td>14.44</td>
<td>105.370</td>
<td>987</td>
<td>101.1</td>
<td></td>
</tr>
<tr>
<td>2. Barometric Pressure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Steam Turbine Exhaust Pressure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Steam Turbine Exhaust Mass Flowrate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Steam Turbine Exhaust Enthalpy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Steam Turbine Exhaust Temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Steam Turbine Exhaust Energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Site Elevation Above Sea Level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>437.8</td>
<td></td>
</tr>
<tr>
<td>9. Auxiliary Power Consumption*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>By Seller</td>
</tr>
</tbody>
</table>

### AIR COOLED CONDENSER DATASHEET

#### DESCRIPTION

<table>
<thead>
<tr>
<th>Units</th>
<th>SPEC DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### OPERATING RANGE (by Engineer)

<table>
<thead>
<tr>
<th>°F</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>93</td>
<td>N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>°F</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>-66</td>
<td>N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>kpph</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>105,510</td>
<td>N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>in HgA</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>°F</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>169</td>
<td>N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>in HgA</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>°F</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>179</td>
<td>N/A</td>
</tr>
</tbody>
</table>
### Air Cooled Condenser

#### Equipment Name: Air Cooled Condenser 33-ACC-ACCU-001

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>Units</th>
<th>SPEC DATA</th>
<th>VENDOR DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Fan Power Referred to Motor Input Side</td>
<td>kW</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Maximum Sound Pressure Level at 3 feet from perimeter of ACC</td>
<td>dBA</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Turbine Exhaust Pressure (measured at turbine exhaust flange)</td>
<td>in HgA</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Minimum Continuous Steam Turbine Exhaust Mass Flowrate to Prevent Freezing</td>
<td>kpph</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Heat Rejection Rate</td>
<td>btu/hr</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Auxiliary Steam Consumption**</td>
<td>lb/hr</td>
<td>By Seller</td>
<td></td>
</tr>
</tbody>
</table>

*Auxiliary power consumption listed here shall be for the entire condensing system and associated equipment.
** Auxiliary steam consumption listed here shall be for the SJAE (Holding)

### Condenser

#### Equipment Name: Condenser

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>Units</th>
<th>SPEC DATA</th>
<th>VENDOR DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Operating Conditions

<table>
<thead>
<tr>
<th>Description</th>
<th>Units</th>
<th>SPEC DATA</th>
<th>VENDOR DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam flow</td>
<td>lb/hr</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Steam exhaust enthalpy</td>
<td>btu/lb</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Condenser pressure</td>
<td>in. Hg.</td>
<td>Same as ACC</td>
<td></td>
</tr>
<tr>
<td>Circulating water flow required</td>
<td>gpm</td>
<td>770</td>
<td></td>
</tr>
<tr>
<td>Circulating water inlet design temperature</td>
<td>ºF</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>Circulating water outlet design temperature</td>
<td>ºF</td>
<td>97</td>
<td></td>
</tr>
<tr>
<td>Circulating water pressure drop</td>
<td>ft</td>
<td>&lt;24*</td>
<td></td>
</tr>
<tr>
<td>Avg. circulating water tube velocity</td>
<td>ft/sec</td>
<td>8.0 Max</td>
<td></td>
</tr>
<tr>
<td>Heat rejected to chilled water at design flow</td>
<td>btu/sec</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Cleanliness factor</td>
<td>%</td>
<td>85</td>
<td></td>
</tr>
</tbody>
</table>

### Auxiliary/Bleed Steam Conditions (by Engineer)

<table>
<thead>
<tr>
<th>CONDITIONS</th>
<th>SPEC DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auxiliary Steam</td>
<td></td>
</tr>
<tr>
<td>a. Operating Pressure</td>
<td>psig</td>
</tr>
<tr>
<td>b. Maximum Temperature</td>
<td>ºF</td>
</tr>
</tbody>
</table>
### AIR COOLED CONDENSER

**DATASHEET**

#### Guaranteed Noise Output - Sound Pressure Levels (dB)

<table>
<thead>
<tr>
<th>Octave Band Distance</th>
<th>63</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>4000</th>
<th>8000</th>
</tr>
</thead>
<tbody>
<tr>
<td>25'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>150'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Notes:

1. Sound pressure level given is decibels (dB) relative to standard reference pressure of 0.0002 Dynes/sq cm. Distances listed are from base of ACC.
2. Reference noise requirements in Section 48 11 17 - Air Cooled Condenser
<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>Units</th>
<th>SPEC DATA</th>
<th>VENDOR DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GENERAL</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td>N/A</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Manufacturer Location</td>
<td>N/A</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Method of Shipment</td>
<td>N/A</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Air Condenser Type or Model Number</td>
<td>N/A</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Overall dimensions of condenser array (W x L)</td>
<td>ft-in</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Height from grade to fan deck</td>
<td>ft-in</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Condenser weight, empty</td>
<td>lb</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Condenser weight, operating</td>
<td>lb</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Number of bays/cells</td>
<td>N/A</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Number of fans</td>
<td>N/A</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Number of roof sections</td>
<td>N/A</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Total extended heat exchange surface area</td>
<td>ft²</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Number of tube bundles</td>
<td>N/A</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Number of cells</td>
<td>N/A</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Weight of each tube bundle</td>
<td>lb</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Windwall height</td>
<td>ft</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Main steam turbine exhaust duct diameter</td>
<td>in</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Branch steam turbine exhaust duct diameter,</td>
<td>in</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Minimum continuous steam flow to ACC necessary to prevent freezing at -60 °F</td>
<td>lb/hr</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td><strong>FIN TUBE BUNDLES</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td>N/A</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Core tube material</td>
<td>N/A</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Tube diameter/wall thickness</td>
<td>in</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Fin material</td>
<td>N/A</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Fin thickness</td>
<td>in</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Fin pitch, No. fins/inch</td>
<td>in</td>
<td>Maximum 11</td>
<td></td>
</tr>
<tr>
<td>Method of fin attachment</td>
<td>N/A</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Type of tube to tube sheet joint</td>
<td>N/A</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Rows of tubes</td>
<td>N/A</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Tube length</td>
<td>ft-in</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Bundle width/length</td>
<td>ft-in</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Bundle weight</td>
<td>lb</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Number of bundles</td>
<td>N/A</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Bundle frame surface treatment</td>
<td>N/A</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Percent of tube bundle area that can be water wash cleaned</td>
<td>N/A</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>Category</td>
<td>Item Description</td>
<td>Manufacturer</td>
<td>By Seller</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
<td>--------------</td>
<td>--------------------</td>
</tr>
<tr>
<td><strong>FANS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td>Fan blade material</td>
<td></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td>Fan diameter</td>
<td></td>
<td>ft-in</td>
<td>By Seller</td>
</tr>
<tr>
<td>Number of blades per fan</td>
<td></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td>Fan rpm, high speed/low speed</td>
<td></td>
<td>rpm</td>
<td>By Seller</td>
</tr>
<tr>
<td>Fan tip speed</td>
<td></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td>Fan shaft power, high speed/low speed</td>
<td></td>
<td>hp</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>GEAR DRIVES</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td></td>
<td>N/A</td>
<td>By Seller (per 01 63 00)</td>
</tr>
<tr>
<td>Model no.</td>
<td></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td>Type</td>
<td></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td>Reduction ratio</td>
<td></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td>AGMA service factor (refer to motor nameplate rating)</td>
<td></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>RUPTURE DISCS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure required to rupture disc</td>
<td></td>
<td>psia</td>
<td>By Seller</td>
</tr>
<tr>
<td>Number provided</td>
<td></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td>Manufacturer</td>
<td></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>EXHAUST NECK EXPANSION JOINT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Make and Type</td>
<td></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td>Material</td>
<td></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td>End Preparation</td>
<td></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>DRAIN PUMPS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td></td>
<td>N/A</td>
<td>By Seller (per 01 63 00)</td>
</tr>
<tr>
<td>Quantity</td>
<td></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td>Type</td>
<td></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td>Flow rate, GPM</td>
<td></td>
<td>gpm</td>
<td>By Seller</td>
</tr>
<tr>
<td>Efficiency, %</td>
<td></td>
<td>%</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>STEAM JET AIR EJECTOR (HOLDING)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td>Model no., size</td>
<td></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td>Number of Stages</td>
<td></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td>Capacity per Train</td>
<td></td>
<td>scfm</td>
<td>By Seller</td>
</tr>
<tr>
<td>Steam Consumption</td>
<td></td>
<td>lb/hr</td>
<td>By Seller</td>
</tr>
<tr>
<td>Motive Steam Pressure</td>
<td></td>
<td>psig</td>
<td>125</td>
</tr>
<tr>
<td>Motive Steam Temperature</td>
<td></td>
<td>F</td>
<td>400</td>
</tr>
<tr>
<td>Materials of Construction</td>
<td></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td>Ejectors</td>
<td></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td>Condenser Shell</td>
<td></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td>Condenser Tubes</td>
<td></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td>Dimensions LxWxH</td>
<td></td>
<td>ft</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Operating Weight</strong></td>
<td>lb</td>
<td>By Seller</td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>----</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td>Skid Mounted</td>
<td>N/A</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

**STEAM JET AIR EJECTOR (HOGGING)**

<table>
<thead>
<tr>
<th><strong>Manufacturer</strong></th>
<th>N/A</th>
<th>By Seller</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model no., size</strong></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Number of Stages</strong></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Capacity per Train</strong></td>
<td>scfm</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Steam Consumption</strong></td>
<td>lb/hr</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Motive Steam Pressure</strong></td>
<td>psig</td>
<td>125</td>
</tr>
<tr>
<td><strong>Motive Steam Temperature</strong></td>
<td>F</td>
<td>400</td>
</tr>
<tr>
<td><strong>Materials of Construction</strong></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Ejectors</strong></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Condenser Shell</strong></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Condenser Tubes</strong></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Dimensions LxWxH</strong></td>
<td>ft</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Operating Weight</strong></td>
<td>lb</td>
<td>By Seller</td>
</tr>
<tr>
<td>Skid Mounted</td>
<td>N/A</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**VACUUM PUMP DESIGN**

<table>
<thead>
<tr>
<th><strong>Manufacturer</strong></th>
<th>N/A</th>
<th>By Seller</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of pumps</strong></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Capacity per pump</strong></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Power consumption per pump</strong></td>
<td>hp</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Pressure maintained</strong></td>
<td>in. Hg.</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Total fluid evacuated</strong></td>
<td>lb/hr</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Dry air evacuated</strong></td>
<td>lb/hr</td>
<td>By Seller</td>
</tr>
</tbody>
</table>

**Sealing Fluid**

| **Design inlet temperature** | °F | By Seller |
| **Maximum discharge temperature** | °F | By Seller |
| **Type of fluid** | | By Seller |
| **Fluid density** | lb/ft³ | By Seller |
| **Vapor Pressure** | psia | By Seller |
| **Overall vacuum pump skid length** | ft-in | |
| **Overall vacuum pump skid width** | ft-in | |
| **Overall vacuum pump skid height** | ft-in | |
| **Vacuum pump skid weight** | lb | |

**MOTOR OPERATED VALVES**

<table>
<thead>
<tr>
<th><strong>Manufacturer</strong></th>
<th>N/A</th>
<th>By Seller (per 01 63 00)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quantity</strong></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
</tbody>
</table>

**LOUVERS**

<table>
<thead>
<tr>
<th><strong>Manufacturer</strong></th>
<th>N/A</th>
<th>By Seller (per 01 63 00)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quantity</strong></td>
<td>N/A</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Total Face Area</strong></td>
<td>ft²</td>
<td>By Seller</td>
</tr>
<tr>
<td>---------------------</td>
<td>-----</td>
<td>-----------</td>
</tr>
<tr>
<td><strong>Pressure Drop at Design Conditions</strong></td>
<td>inH₂O</td>
<td>By Seller</td>
</tr>
</tbody>
</table>

**LOUVER ACTUATORS**

<table>
<thead>
<tr>
<th><strong>Manufacturer</strong></th>
<th>N/A</th>
<th>By Seller (per 01 63 00)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power consumption</strong></td>
<td>kW</td>
<td>By Seller</td>
</tr>
</tbody>
</table>

**STEEL**

<table>
<thead>
<tr>
<th><strong>Supplier</strong></th>
<th>N/A</th>
<th>By Seller (per 01 63 00)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quantity</strong></td>
<td>tons</td>
<td>By Seller</td>
</tr>
</tbody>
</table>

**OTHER OPERATING CONDITIONS**

1) Air Side Performance
   a. Total net tube bundle face area, square feet | ft² | By Seller |
   b. Total fan air flow, (all cells) | acfm | By Seller |
   c. Air flow velocities | ft/sec | By Seller |
      1. At air inlet perimeter | ft/sec | By Seller |
      2. Face velocity entering fin tube bundle | ft/sec | By Seller |
   d. Pressure Drops | N/A | By Seller |
      1. Air inlet to fan bell inlet | in. Hg. | By Seller |
      2. Across fan guard screen and fan bridge | in. Hg. | By Seller |
      3. Dynamic loss | in. Hg. | By Seller |
      4. Across bundles | in. Hg. | By Seller |
      5. Natural Draft | in. Hg. | By Seller |
      6. Turning loss (entering and exiting fin tube bundle) | in. Hg. | By Seller |
      7. Additional losses | in. Hg. | By Seller |
      8. Total static pressure loss | in. Hg. | By Seller |

2) Condensate Flow
   a. Maximum dissolved O₂ level | ppb | By Seller |
   b. Non-condensable gas (NCG) | N/A | By Seller |
      1. Design Flow | lb/hr | By Seller |
      2. Minimum Flow | lb/hr | By Seller |
      3. Maximum Flow | lb/hr | By Seller |
   c. NCG Maximum Exit Temperature, °F | °F | By Seller |
   d. NCG Exit Pressure, in HgA | in. Hg. | By Seller |
   e. Air Inleakage, lb/hr | lb/hr | By Seller |
   f. Maximum nondeaerated condensate makeup | gpm | By Seller |
   g. Hotwell subcooling at design conditions | °F | By Seller |

**ERECITION DATA**

| **Estimated man hours for field erection** | hours | By Seller |
| **Field welding required, size and length** | linear ft | By Seller |
| **Number of sections as shipped** | N/A | By Seller |
| **Largest Section:** | | |

University of Alaska Fairbanks

RFP No. 15P0015MG - Air-Cooled Condensing System

Amendment No. 5
<table>
<thead>
<tr>
<th>Dimensions</th>
<th>ft x ft x ft</th>
<th>Weight</th>
<th>lb</th>
<th>By Seller</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DESCRIPTION</td>
<td>Units</td>
<td>SPEC DATA</td>
<td>VENDOR DATA</td>
<td></td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-------</td>
<td>-----------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td><strong>CONDENSER TUBE DESIGN</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total effective surface area</td>
<td>ft²</td>
<td>By Seller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of passes</td>
<td>N/A</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of tubes</td>
<td>N/A</td>
<td>By Seller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tube material</td>
<td>N/A</td>
<td>By Seller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tube outside diameter</td>
<td>in</td>
<td>By Seller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tube inside diameter</td>
<td>in</td>
<td>By Seller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tube wall thickness</td>
<td>in</td>
<td>By Seller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tube length</td>
<td>ft</td>
<td>By Seller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tube pitch</td>
<td>in</td>
<td>By Seller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tube design pressure:</td>
<td>psig</td>
<td>By Seller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tube design temperature</td>
<td>ºF</td>
<td>By Seller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tube support spacing</td>
<td>ft</td>
<td>5’ Max</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condenser tube thermal conductivity</td>
<td>btu-in./hr-ft·ºF</td>
<td>By Seller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condenser fouling factor</td>
<td>(btu-in./hr-ft²·ºF)⁻¹</td>
<td>By Seller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condenser external h.t.c./Laminar film h.t.c.</td>
<td>N/A</td>
<td>By Seller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensate sub cooling</td>
<td>ºF</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computed external h.t.c.</td>
<td>(btu-in./hr-ft²·ºF)</td>
<td>By Seller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computed external h.t.c.</td>
<td>(btu-in./hr-ft²·ºF)</td>
<td>By Seller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computed overall h.t.c.</td>
<td>(btu-in./hr-ft²·ºF)</td>
<td>By Seller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computed overall UA</td>
<td>btu-in./sec-ft·ºF</td>
<td>By Seller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal Reynolds Number</td>
<td>N/A</td>
<td>By Seller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Prandtl Number</td>
<td>N/A</td>
<td>By Seller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal Nusselt Number</td>
<td>N/A</td>
<td>By Seller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water box design pressure</td>
<td>psig</td>
<td>75</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CONDENSER SHELL DESIGN</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PROPOSED PRODUCTS FORM</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SECTION 3418.00 43 33 - Condenser Equipment - Page 11</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Sheel material</strong></th>
<th>N/A</th>
<th>By Seller</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nominal shell thickness</strong></td>
<td>in</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Shell design pressure</strong></td>
<td>psig</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Shell design temperature</strong></td>
<td>ºF</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Hotwell capacity</strong></td>
<td>gal</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Steam inlet connection (size/rating)</strong></td>
<td>in</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Chilled Water(size/rating)</strong></td>
<td>in</td>
<td>8&quot; #150</td>
</tr>
<tr>
<td><strong>Condensate outlet connection(size/rating)</strong></td>
<td>in</td>
<td>By Seller</td>
</tr>
</tbody>
</table>

**PHYSICAL DATA**

<table>
<thead>
<tr>
<th><strong>Maximum Condenser Shipping Dimensions</strong></th>
<th>ft-in</th>
<th>By Seller</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(W x H x L)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Condenser maximum width</strong></td>
<td>ft-in</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Overall condenser unit length</strong></td>
<td>ft-in</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Overall condenser unit width</strong></td>
<td>ft-in</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Overall condenser unit height</strong></td>
<td>ft-in</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Condenser weight:</strong></td>
<td></td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Dry</strong></td>
<td>lb</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Operating</strong></td>
<td>lb</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Flooded</strong></td>
<td>lb</td>
<td>By Seller</td>
</tr>
<tr>
<td>DESCRIPTION</td>
<td>Units</td>
<td>SPEC DATA</td>
</tr>
<tr>
<td>------------------------------------</td>
<td>-------</td>
<td>-----------</td>
</tr>
<tr>
<td><strong>Design</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor Seller</td>
<td></td>
<td>By Seller</td>
</tr>
<tr>
<td>Motor Catalog No.</td>
<td></td>
<td>By Seller</td>
</tr>
<tr>
<td>IEEE 841 design standards motor</td>
<td>Y/N</td>
<td>By Seller</td>
</tr>
<tr>
<td><strong>Ratings:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System Voltage (208, 240, 480, 600)</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Operating Frequency (50 or 60)</td>
<td>Hz</td>
<td>60</td>
</tr>
<tr>
<td>Nameplate Voltage (200, 230, 460, 575)</td>
<td>V&lt;sub&gt;t&lt;/sub&gt;</td>
<td></td>
</tr>
<tr>
<td>Frame Size</td>
<td>Qty</td>
<td>3</td>
</tr>
<tr>
<td>Number of Phases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rated Speed</td>
<td>RPM</td>
<td>By Seller</td>
</tr>
<tr>
<td>Rated Shaft Output</td>
<td>hp</td>
<td>By Seller</td>
</tr>
<tr>
<td>Driven Load (maximum)</td>
<td>hp</td>
<td>By Seller</td>
</tr>
<tr>
<td>Design Type (A, B, C, D, E)</td>
<td></td>
<td>By Seller</td>
</tr>
<tr>
<td>Locked Rotor Code Letter</td>
<td></td>
<td>By Seller</td>
</tr>
<tr>
<td>Protective Enclosure IP Code (NEMA MG-1 Part 5)</td>
<td>IP</td>
<td>IP 44/54</td>
</tr>
<tr>
<td>Minimum Efficiency (NEMA Defined)</td>
<td></td>
<td>Premium Efficiency</td>
</tr>
<tr>
<td>Method of Cooling IC Code (NEMA MG-1 Part 6)</td>
<td>IC</td>
<td></td>
</tr>
<tr>
<td><strong>Installation:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Site Design Ambient Temp</td>
<td>°C</td>
<td>40</td>
</tr>
<tr>
<td>Minimum Site Design Ambient Temp</td>
<td>°C</td>
<td>-25</td>
</tr>
<tr>
<td>Site Altitude</td>
<td>ft</td>
<td>≤ 3300</td>
</tr>
<tr>
<td>Unusual Service Conditions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Insulation Class (B, F, or H)</td>
<td></td>
<td>F (minimum)</td>
</tr>
<tr>
<td>Maximum Operating Temperature Rise (B, F, or H)</td>
<td></td>
<td>B (Maximum)</td>
</tr>
<tr>
<td>Service Factor</td>
<td></td>
<td>1.15</td>
</tr>
<tr>
<td>Duty Type (Continuous, short-time, or intermittent)</td>
<td></td>
<td>Continuous</td>
</tr>
<tr>
<td>No. of Speeds</td>
<td>1, 2 Variable</td>
<td>1</td>
</tr>
<tr>
<td>No. of Windings</td>
<td>1, 2</td>
<td>1</td>
</tr>
<tr>
<td>Motor Starting Method</td>
<td></td>
<td>VFD</td>
</tr>
<tr>
<td>Type of Speed Control</td>
<td></td>
<td>Variable Speed</td>
</tr>
<tr>
<td>Motor Rated for Use With VFD</td>
<td>Y/N</td>
<td></td>
</tr>
<tr>
<td>Bearing Type</td>
<td></td>
<td>By Seller</td>
</tr>
<tr>
<td>Motor Space Heater required:</td>
<td>Y/N</td>
<td></td>
</tr>
<tr>
<td>Rated Voltage</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Operating Voltage</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Wattage</td>
<td>W</td>
<td>By Seller</td>
</tr>
<tr>
<td>Weight</td>
<td>Lb</td>
<td>By Seller</td>
</tr>
<tr>
<td>Nonreversing Ratchets</td>
<td>Y/N</td>
<td></td>
</tr>
</tbody>
</table>

Seller shall duplicate this sheet for each motor type being provided

Rev. 0
# LOW VOLTAGE VARIABLE FREQUENCY DRIVES

**DATA SHEET**

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>Units</th>
<th>SPEC DATA</th>
<th>VENDOR DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturer</td>
<td>N/a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catalog/Serial No.</td>
<td>N/a</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>General</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driven Equipment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor NEMA Design</td>
<td></td>
<td>NEMA</td>
<td>Design B</td>
</tr>
<tr>
<td>Nominal Operating Voltage</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>System Operating Frequency</td>
<td>Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor Nameplate Voltage</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor Nameplate Horsepower</td>
<td>Hp</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cable information:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Cable Incoming Location</td>
<td>Top/Bottom</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Cable Exit Location</td>
<td>Top/Bottom</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Expected Cable Length</td>
<td>ft</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Site information:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Ambient Temperature</td>
<td>°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Ambient Temperature</td>
<td>°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Design:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rectifier Type</td>
<td>-</td>
<td>PWM</td>
<td></td>
</tr>
<tr>
<td>No of Pulses, Minimum</td>
<td>12, 18, or 24</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>THD at Point of Common Coupling (PCC)</td>
<td>%</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Available Short Circuit Current at PCC</td>
<td>kA</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Mean Time Between Failure (MTFB), Minimum</td>
<td>Hrs</td>
<td>50,000</td>
<td></td>
</tr>
<tr>
<td>Maximum Input Voltage Variation</td>
<td>%</td>
<td>+/- 10</td>
<td></td>
</tr>
<tr>
<td>Maximum Input Frequency Variation</td>
<td>%</td>
<td>+/- 5</td>
<td></td>
</tr>
<tr>
<td>Drive Efficiency, Minimum</td>
<td>%</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>Displacement Power Factor, minimum</td>
<td>pu</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>Programmable Output Voltage Range</td>
<td>V - V</td>
<td>320 – 480</td>
<td></td>
</tr>
<tr>
<td>Overvoltage Capability of System Voltage, Min.</td>
<td>%</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td>Speed Range</td>
<td>Hz - Hz</td>
<td>6 – 60</td>
<td></td>
</tr>
<tr>
<td>Minimum Programmable Prohibited Freq. Ranges</td>
<td>Qty</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Prohibited Freq. Range Span</td>
<td>Hz - Hz</td>
<td>0 – 10</td>
<td></td>
</tr>
<tr>
<td><strong>Enclosure:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEMA Rating</td>
<td>NEMA</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Dimensions</td>
<td>L x W x H</td>
<td>By Manufacturer</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>lbs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooling Method</td>
<td>Air/Water</td>
<td>By Manufacturer</td>
<td></td>
</tr>
<tr>
<td><strong>Controls:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local /Remote Switch</td>
<td>Y/N</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Start and Stop Push Buttons</td>
<td>Y/N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local Speed Reference Potentiometer/Adjustment</td>
<td>Y/N</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Programmable Speed Setting</td>
<td>Y/N</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Local LCD or LED Readout Panel</td>
<td>Y/N</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Local and Remote Alarm Indication</td>
<td>Y/N</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Monitoring of VFD Fault Conditions</td>
<td>Y/N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication Interface</td>
<td>-</td>
<td>DeviceNet</td>
<td></td>
</tr>
<tr>
<td><strong>Accessories:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Isolation Transformer</td>
<td>Y/N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Line Reactor</td>
<td>Y/N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Harmonic Filter Trap with Series Reactor</td>
<td>Y/N</td>
<td>By Manufacturer</td>
<td></td>
</tr>
<tr>
<td>Output Filter</td>
<td>Y/N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mirus Filter</td>
<td>Y/N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DC Link Reactor</td>
<td>Y/N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special Accessories Required (Provide list)</td>
<td>Y/N</td>
<td>By Manufacturer</td>
<td></td>
</tr>
</tbody>
</table>

**Equipment Name:** [SELLER TO FILL IN]

**Tag No.:**

---

*Seller shall duplicate this sheet for each type of VFD being offered*

Rev. 0
# FIELD SERVICES DATA SHEET

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>Units</th>
<th>SPEC DATA</th>
<th>VENDOR DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated field service personnel time included in bid (ACC)</td>
<td>man-days</td>
<td>by SELLER</td>
<td></td>
</tr>
<tr>
<td>Estimated field service personnel time included in bid (Condenser)</td>
<td>man-days</td>
<td>by SELLER</td>
<td></td>
</tr>
</tbody>
</table>
PART 1   GENERAL

1.01 USE OF TECHNICAL SPECIFICATIONS FOR BIDDING PURPOSES

A. The technical specifications provided in this Annex (Annex A) are intended to define the required scope of this contract and to indicate a representative level of quality that the Buyer will require from the Seller.

B. The technical specifications have been intentionally written to be generic in nature so as not to indicate a preference for one Seller over another.

C. The Buyer encourages each Seller to submit their standard design that best fits the performance requirements identified in Section 00 43 33 of this RFP.

D. Deviations between the Seller’s standard design and the design called for in this RFP shall be detailed as a clarification in the Seller’s proposal.
   1. The Seller is encouraged to highlight and expand upon these clarifications in attachments to their proposal. Additional details should be provided for any clarification that the Seller feels would bring significant benefit to the Buyer in terms of capital cost, ease of installation/erection, efficiency, ease of operation, reduced maintenance, or extended operational life.

E. Sellers will not be penalized for clarifications that, in the opinion of the Buyer, are necessary to allow the Seller to propose their standard design.

F. The Buyer requests that the Sellers adhere to any technical requirements that will not directly impact the Seller’s standard design. This includes quality requirements, approved vendors, design minimums, design maximums, requirements for commodities (pipe, wire, steel, conduit) and associated components, and types of major auxiliary equipment such as motors, electrical gear, fans, and gland steam condenser.

G. These technical specifications will be conformed to match the winning Seller’s scope of supply prior to contract signing.

1.02 PROJECT BACKGROUND

A. The existing coal boilers in the Ben Atkinson Heat and Power Plant, located on the University of Alaska Fairbanks (“UAF” or “the University”) campus in Fairbanks, Alaska, were constructed in 1964 and require either significant renewal or replacement to continue to provide heat and power to the University campus. UAF has made the decision to replace the existing coal boilers and auxiliary equipment with a new combined heat and power plant that will be fueled with a combination of coal and biomass (future).

1.03 PROJECT DESCRIPTION

A. The project consists of the installation of a new coal-fired CFB Boiler to replace and augment existing steam generation capacity. The boiler shall also be capable of co-firing up to 15% biomass. The two existing coal-fired, stoker-type boilers will be decommissioned upon startup of the new boiler. The replacement project also includes the installation of a new 17 MW (gross) steam turbine-generator (STG), an air-cooled condenser heat rejection system, required auxiliary equipment, and process and utility connections to the existing facility. The equipment procured for this project will be housed in a new facility consisting of a boiler building, and a turbine building in adjoining structures.

B. The project intends to use the Air Cooled Condenser (ACC) to condense the maximum amount of exhaust steam from the turbine at the extreme minimum to extreme maximum ambient temperatures, defined in Section 00 43 33. The ACC system will work to achieve the required backpressure as defined in Section 00 43 33 and Section 01 86 36.
1.04 WORK COVERED BY CONTRACT DOCUMENTS

A. Work of this Agreement comprises design, procurement, manufacture, and delivery to the job site of an Air Cooled Condenser and Surface Steam Condenser for The University of Alaska Fairbanks Coal-Fired Boiler Replacement Project located on the university campus in Fairbanks, Alaska. Work under this contract includes, but is not limited to, the items identified in this Section and in the following documents:
   1. Terminal Points list (TP) as delineated in Section 01 18 00
   2. Division of Responsibility (DOR) as delineated in Section 01 11 00

B. Work on Project identified as being supplied by others will be executed under separate contracts, and is excluded from this Agreement. Reference Paragraph 1.06 of this Section and the Division of Responsibility (DOR) provided in Section 01 11 00

1.05 GENERAL SCOPE OF SUPPLY

A. Design, manufacture, and deliver one air cooled condenser. Auxiliary components for proper operation, function, control, and monitoring of units shall be included. Units shall be fully compatible and matched with electric generator and accessories.

B. Structural Components:
   1. Structural steel to support the Air Cooled Condenser tube bundles and associated piping.
   2. Structural steel for skidded components and means for anchoring the air cooled condenser and surface condenser equipment to the foundations provided by others.
   3. Design information / specifications for all equipment and structure foundations, as well as for any elevated floors or platforms.
   4. Coordination with Steam Turbine Generator Vendor for exhaust flange connection size, details, and loads.

C. Design information as required for Engineer to design and specify interfacing equipment and piping as well as building HVAC systems.

D. Turbine Exhaust Duct, including duct isolation valves as required by the Sellers design for freeze protection.

E. Steam Surface Condenser

F. Variable Frequency Drives

G. Liquid Ring Vacuum Pump

H. Steam Jet Air Ejector (SJAE)

I. Steam Hogging Ejector

J. Expansion Joints, including the expansion joint at the turbine exhaust flange.

K. Pipe Supports and Piping within skid limits unless specified otherwise.

L. Logic for condensing system control system to be integrated into Buyer’s DCS.

M. DCS FAT testing attendance.

N. Painting and coating:
   1. Insulated or high temperature components provided with prime coat of paint suitable for intended service.
   2. Fabricated components per Section 09 92 00.
   3. Equipment and off the shelf components manufacturer standard paint system. No field painting.
4. Provide paint and/or primer material only for field touch-up by others.

O. Quality assurance program.

P. Packaging and DDP delivery to site (per Incoterms 2010) for all supplied equipment.

Q. Erection advisory field services

R. Commissioning advisory field services

S. Startup and testing advisory field services

T. Performance testing advisory services for performance guarantees.

U. Equipment tagging in accordance with Buyer’s equipment identification system.

V. O&M Manuals

W. Special Tools and Accessories

X. Spare Parts and Consumables for first year of operation

1.06 WORK BY OTHERS

A. Foundation, anchor bolts, and building Work.

B. Installation of materials and equipment furnished under this contract.

C. Furnishing and installing motor control centers.

D. Furnishing and installing piping, insulation, and wiring to equipment furnished under this contract, external to air cooled condenser and surface condenser and associated equipment skids, unless otherwise noted.

E. Integrating condensing system control system into Buyer’s facility control system.

F. Furnishing and installing external insulation and lagging for following: Piping, expansion bellows, and ducting between steam turbine and condenser except as otherwise noted.

G. Installation of instruments and associated tubing, wiring, and conduit for "nonskid mounted" equipment furnished under this contract, unless otherwise noted.

H. Connection to Site utilities.

I. Unloading of equipment at Buyer’s Site.

J. Deaerator.

K. Miscellaneous equipment pads at grade level.

L. Chemical and steam cleaning including disposal.

M. Utilities (compressed air, cooling water) required by Seller supplied equipment.

N. Electrical supply for all loads.

O. Welding outlets and receptacles.
P. Lighting
Q. Lightning protection.
R. Grounding system.
S. Fire protection and detection.
T. Plumbing.
U. Plant drains and sumps.
V. Chemical treatment system.
W. Plant Distributed Control System
X. Electrical raceway, power, control and instrumentation cables for all connections.
Y. Field painting.

1.07 COORDINATION AND REVIEW MEETINGS:
A. Seller’s Project Engineer for condensing system shall attend two 1-day coordination and review meetings in Fairbanks, Alaska at Buyer’s Project Site and/or Denver, Colorado.
B. First meeting will be coordination meeting shortly after contract award. Second meeting will be review meeting scheduled following submittal of general arrangement drawings, one-line diagrams, equipment lists, etc.
C. Seller’s Project Engineer for condensing system shall attend 6 construction meetings in Fairbanks, Alaska at Buyer’s Project Site throughout installation of condensing system equipment by others. Buyer will schedule meetings.
D. Costs for personnel and round trip expenses for coordination and review meetings specified shall be included as part of base bid and shall be in addition to days specified in Section 01 43 33 for service Engineer.

1.08 WORK SEQUENCE
A. Work to accommodate Buyer’s project schedule. Coordinate schedule and operations with Buyer.
B. Anticipated schedule:
1. Erection work by other complete by: (TBD) Months from Full Notice to Proceed.
2. ACC and Surface Condenser Testing and Commissioning: (TBD) Months from Full Notice to Proceed.
3. Performance Testing completed by: (TBD) Months from Full Notice to Proceed.
4. Final Acceptance: (TBD) Months after performance testing
5. Final Payment: (TBD) Months after final acceptance.

PART 2 PRODUCTS
NOT USED

PART 3 PRODUCTS
NOT USED

END OF SECTION
<table>
<thead>
<tr>
<th>Area/System</th>
<th>Item</th>
<th>Seller</th>
<th>Others</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Cooled Condenser</td>
<td>Air Cooled Condenser</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Cooled Condenser</td>
<td>Steam duct between the steam turbine exhaust flange and the ACC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Cooled Condenser</td>
<td>Finned Tube Bundles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Cooled Condenser</td>
<td>ACC fans</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Cooled Condenser</td>
<td>ACC fan motors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Cooled Condenser</td>
<td>ACC fan VFD's</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Cooled Condenser</td>
<td>ACC Fan Gearboxes, Couplings, Guards, Bells, Rings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Cooled Condenser</td>
<td>Liquid Ring Vacuum Pump Skid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Cooled Condenser</td>
<td>Steam Jet Air Ejector</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Cooled Condenser</td>
<td>Steam Hogging System</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Cooled Condenser</td>
<td>Expansion Joint Piece at Turbine Exhaust</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Cooled Condenser</td>
<td>Partition Walls, Access Doors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Cooled Condenser</td>
<td>Windwall Sliding and Steel Support</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Cooled Condenser</td>
<td>Steel structure and platforms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Cooled Condenser</td>
<td>Interconnecting Piping Within ACC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Cooled Condenser</td>
<td>High Pressure Water Washing System and Accessories</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steam Surface Condenser</td>
<td>Surface Condenser</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steam Surface Condenser</td>
<td>Hotwell</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steam Surface Condenser</td>
<td>Expansion Joint Piece at ACC Duct</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Components</td>
<td>Monorail(s)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Components</td>
<td>Electric Hoist(s) and Lifting Equipment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Components</td>
<td>Compressed air, water, and power supply on site</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Components</td>
<td>Deaerator</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Components</td>
<td>MP Feedwater Heater</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Components</td>
<td>District Water Heaters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Components</td>
<td>Drain Pipes From Duct Low Point</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Components</td>
<td>Insulation of Delivered Piping</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Components</td>
<td>Heat Insulation of the Piping (Off-Skid)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Components</td>
<td>Heat Insulation of the Gland Steam Condenser</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Components</td>
<td>Anchor Bolts, Nuts, Sole Plates for Delivered Equipment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Components</td>
<td>Rupture Disc to Protect Turbine Exhaust (Loose Item, to be installed on ACC Duct)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Components</td>
<td>Noise Attenuation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field Instrumentation</td>
<td>Local measuring instruments on delivered equipment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field Instrumentation</td>
<td>Sensors for Remote Measurement, Control, Protections and Open Loop Control Necessary for Air Cooled Condensing System and Condenser Operation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field Instrumentation</td>
<td>Instrument's Impulse Piping from Stainless Steel (for Pressure Measurement)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field Instrumentation</td>
<td>PTs with LCD Display</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field Instrumentation</td>
<td>Measuring Transducers 4-20mA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field Instrumentation</td>
<td>Sensors and Tap Points for Direct DCS Use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field Instrumentation</td>
<td>Fan Vibration Monitoring</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbine Local Cubicle w remote IO modules</td>
<td>Turbine Local Control Panel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Services</td>
<td>Supervision of Erection and Commissioning of the Supplied Equipment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Services</td>
<td>Site Training Within the Commissioning Period</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Services</td>
<td>Factory Test</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Services</td>
<td>Labor, Equipment and Tools for Erection of Equipment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Services</td>
<td>Shipping to Site</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Services</td>
<td>Receiving, Unloading, Inspection and Storage at Site</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Services</td>
<td>Witnessed DCS Testing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Documentation</td>
<td>O&amp;M manuals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Documentation</td>
<td>Manufacturing Drawings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Documentation</td>
<td>System Logic Specification in Narrative form for incorporation Into Plant DCS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spare Parts</td>
<td>Spare Parts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Civil</td>
<td>Foundations, Earthworks, Soil Preparation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Civil</td>
<td>Masonry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Civil</td>
<td>Grouting of Baseframe(s) with Non Shrinking Material</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Civil</td>
<td>Heating and Lighting of the Machine House</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Civil</td>
<td>Fire-fighting Device</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical</td>
<td>Lightning Protection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area/System</td>
<td>Item</td>
<td>Seller</td>
<td>Others</td>
<td>Comments</td>
</tr>
<tr>
<td>------------------------------</td>
<td>--------------------------------------------------------</td>
<td>--------</td>
<td>--------</td>
<td>----------</td>
</tr>
<tr>
<td>Electrical</td>
<td>Emergency Lighting System</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Electrical</td>
<td>LV Cables, Cable Traces</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Electrical</td>
<td>DC Distribution and Supply (Battery, Rectifier, Switchboard)</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Electrical</td>
<td>Motor Control Center</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Electrical</td>
<td>Motor Local Control Boxes</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Electrical</td>
<td>Earthing System</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Electrical</td>
<td>Load Shedding System</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Electrical</td>
<td>Load Sharing System</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Instrumentation and Controls</td>
<td>I&amp;C cabling between Seller Equipment and DCS</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Instrumentation and Controls</td>
<td>I&amp;C Cabling Between Seller Equipment and MCC</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Instrumentation and Controls</td>
<td>DCS system</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Instrumentation and Controls</td>
<td>Control of Equipment Delivered by Others</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Instrumentation and Controls</td>
<td>Central Control Room with Instrumentation, Control &amp; Alarm Annunciation Equipment</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Instrumentation and Controls</td>
<td>UPS 230V, AC, 2kW, 30 min</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Instrumentation and Controls</td>
<td>Fire Detection and Fighting System</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>
PART 1    GENERAL

1.01 STEAM CONNECTIONS

A. Steam: At steam turbine exhaust flange.
   1. BUYER will provide shop drawings as they become available.
   2. Exhaust diameter is approximately 70 inches (5 feet 10 inches).

1.02 DRAIN CONNECTIONS

A. Outlet of miscellaneous drain valves.
B. Drains header- low pressure
C. Drains header- turbine steam leads
D. Condenser drains
E. Turbine- seal steam header drain

1.03 WATER CONNECTIONS

A. Inlet of the condensate tank.
B. At the outlet of the condensate tank.
   A. Hotwell pump suction (if required)
   B. Air vapor outlet
   C. Waterbox vent- inlet
   D. Waterbox vent- outlet
   E. Waterbox drain- inlet
   F. Waterbox drain- outlet

1.04 MISCELLANEOUS CONNECTIONS

A. Gland Steam Exhauster Exits
B. Condenser shell vac breaker
C. Conductivity cells for leak detection
D. Hotwell level instrument header
E. Hotwell temperature element
F. Hotwell temperature indicator
G. Hotwell test thermowell
H. Water box level guage glasses
I. Water box pressure  
J. Water box temperature  
K. Miscellaneous Vents  

1.05 COMPRESSED AIR CONNECTIONS  
A. Miscellaneous small compressed air users (valves and instruments)  

1.06 MECHANICAL PARTS CONNECTIONS 
A. Manway- exhaust neck access  
B. Manway- shell  
C. Manway- water box  
D. Sole plates under the baseframes  
E. Connecting terminals of the electric motors  
F. Connecting terminals of the junction boxes  
G. Earthing connection terminals of the electrical equipment  

1.07 WIRING CONNECTIONS 
A. Temperature RTDs with local temperature transmitters shall be supplied by Seller. Junction boxes with associated RTD extension wiring shall be provided for RTD’s located in inaccessible locations. Buyer will install Seller-furnished junction boxes, wiring, and RTDs in Seller’s equipment and piping.  
B. Connecting terminals of the solenoid valves.  
C. Seller-furnished RTDs installed in Buyer supplied piping will be installed by the Buyer.  
D. Motor wiring terminal point for Seller-furnished motors shall be at motor terminals.  
E. Components provided loose (valves, instruments, etc.) for field installation will be installed by Buyer.  
F. Grounding connections will be supplied by Buyer. Grounding terminal point shall be skid/equipment/motor grounding lug.  
G. Terminal point for all control wiring will be at the instrument except as otherwise specified herein.  
H. Structural steel, steam duct, miscellaneous equipment: At bottom base plates.  
I. Controls: Instrument or controller terminal box.  
J. Electrical: Main fan motor terminal boxes and junction boxes.  

PART 2 PRODUCTS  
NOT USED  

PART 3 EXECUTION
NOT USED

END OF SECTION
PART 1  GENERAL

1.01  SUBSTITUTIONS

A. Submit an electronic copy of request for substitution for consideration using attached Product Substitution Request Form. Limit each request to one proposed Substitution. Support each request with:

   a. Product identification, including manufacturer's name and address.
   b. Manufacturer's literature; identify:
      1) Product description.
      2) Reference standards.
      3) Performance and test data.
   c. Samples, as applicable.
   d. Name and address of similar projects on which product has been used, and date of each installation (Only necessary upon Buyers request).

2. Itemized comparison of proposed substitution with product specified; list significant variations.

3. Data relating to changes in Sellers schedule.

4. Any effect of substitution on separate contracts.

5. List of changes required in other work or products.


7. Designation of required license fees or royalties.

8. Designation of availability of maintenance services, sources, or replacement materials.

B. Substitutions will not be considered for acceptance when:

1. They are indicated or implied on Shop Drawings.

2. They are requested directly by any party other than the Seller.

3. Acceptance will require substantial revision of Contract Documents.

C. Substitute products shall not be ordered or installed without written notification from Buyer or Buyer's Representative.

D. Engineer will determine acceptability of proposed substitutions.

1.02  SELLER'S REPRESENTATION

A. In making formal request for substitution Seller represents that:

1. It has investigated proposed product and has determined that it is equal to or superior in all respects to that specified.

2. It will provide same warranties or Bonds for substitution as for product specified or as required by Buyer.

3. It will coordinate installation of accepted substitution into Work, and will make such changes as may be required for Work to be complete in all respects.

4. It waives claims for additional costs caused by substitution which may subsequently become apparent.

5. Cost data is complete and includes related costs under its Agreement, but not:
   a. Costs under separate contracts.
   b. Engineer's costs for redesign or revision of Contract Documents.

1.03  ENGINEER DUTIES

A. Review Seller's requests for substitution with reasonable promptness and advise Buyer.

B. Notify Seller in writing of Buyer's decision to accept or reject requested substitution.
PART 2    PRODUCTS
              
              NOT USED

PART 3    EXECUTION
              
              NOT USED

END OF SECTION

1) J. Solan
1) R. Hernandez
PRODUCT SUBSTITUTION REQUEST FORM

To: 

Project: 

Specified Item: 

The undersigned request consideration of the following:

PROPOSED SUBSTITUTION 

Attached data includes product description, specifications, drawings, photographs, performance, and test data adequate for evaluation of the request; applicable portions of the data are clearly identified.

Attached data also includes a description of changes to the Contract Documents that the proposed substitution will require for its proper installation.

The undersigned certifies that the following paragraphs, unless modified by attachments are correct:

1. The proposed substitution does not affect dimensions shown on Drawings.
2. The undersigned will pay for changes to the building design, including engineering design, detailing, and construction costs caused by the requested substitution.
3. The proposed substitution will have no adverse effect on other trades, the construction schedule, or specified warranty requirements.
4. Maintenance and service parts will be locally available for the proposed substitution.

The undersigned further states that the function, appearance, and quality of the proposed substitution are equivalent or superior to the specified item.

Submitted by:

Signature ________________________________
Firm ________________________________
Address ________________________________

For use by Engineer/Architect

Approved
Approved as noted
Not Approved
Received too late

By ________________________________

Date ________________________________
Telephone ________________________________

Remarks ________________________________

Attachments
PART 1  GENERAL

1.01  COPIES OF DRAWINGS AND PROJECT MANUALS

A. Revised project manuals, if required, will be provided by Engineer in electronic format to show authorized changes or extra Work.

1.02  PROJECT MEETINGS

A. Representatives of the Seller attending meetings shall be qualified and authorized to act on behalf of entity each represents.

B. Kickoff meeting:
   1. Buyer, in coordination with Engineer and Seller, will schedule a meeting after Notice to Proceed at the earliest convenience of all parties. It is intended that the kickoff meeting be held within the first 30 days after the Notice is issued. Reference Section 3418.01 -10 00.
   2. The Engineer will record minutes and distribute electronic copies for review within five (5) working days after meeting to participants. Resolve any comments received and publish final meeting minutes within twenty (20) working days after the meeting.

C. Weekly progress meetings:
   1. Buyer will schedule and administer meetings throughout progress of the Work at weekly intervals, or as agreed to by all parties.
   2. Meetings will be held via an online conference service (GoTo Meeting, Netmeeting, or similar).
   3. Buyer will make arrangements for meetings, prepare agenda with copies for participants, preside at meetings.
   4. Attendance:
      a. Buyer
      b. Engineer, and its professional consultants as needed.
      c. Seller’s Project Manager and Engineers as appropriate to agenda.
      d. Others.
   5. Suggested agenda:
      a. Review, approval of minutes of previous meeting.
      b. Review of Work progress since previous meeting.
      c. Review of Action Item List including items that may impede the design schedule
      d. Review of equipment fabrication, delivery schedules.
      e. Corrective measures and procedures to regain projected schedule, as necessary.
      f. Progress, schedule, during succeeding Work period.
      g. Revisions to design schedule.
      h. Coordination of schedules.
      i. Review submittal schedules; expedite as required.
      j. Maintenance of quality standards.
      k. Pending changes and substitutions.
      l. Review proposed changes for:
         1) Effect on fabrication schedule and on completion date.
         2) Effect on other contracts of Project.
         3) Other business.
   6. The Engineer will record minutes and distribute electronic copies for review within two (2) working days after meeting to participants. Resolve any comments received and publish final meeting minutes within ten (10) working days after the meeting.

D. Design milestone meetings
   1. Attend meetings in accordance with Section 3418.01 -10 00.
   2. The Engineer will record minutes and distribute electronic copies for review within two (2) working days after meeting to participants. Resolve any comments received and publish final meeting minutes within ten (10) working days after the meeting.

PART 2  PRODUCT

NOT USED
PART 3    EXECUTION

NOT USED

END OF SECTION

1) J. Solan
2) R. Hernandez
### PART 1  GENERAL

1.01 DOCUMENT SUBMITTAL SCHEDULE

<table>
<thead>
<tr>
<th>Schedule</th>
<th>Description</th>
<th>Calendar Days after NTP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GENERAL INFORMATION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fabrication, shop testing, and delivery schedule</td>
<td>With RFP</td>
<td>---</td>
</tr>
<tr>
<td>Progress schedule for work, including key dates for engineering, procurement, production, shop testing and delivery</td>
<td>15</td>
<td>10 days after comments returned</td>
</tr>
<tr>
<td>Shop Drawing list and submittal schedule</td>
<td>With RFP</td>
<td>30</td>
</tr>
<tr>
<td>Outline drawings showing equipment general arrangement, platforms, dimensions, space requirements, nameplate data, weights, shipping sections, grounding connections and clearances for access and maintenance</td>
<td>With RFP</td>
<td>45</td>
</tr>
<tr>
<td>Schematic arrangements, flow diagrams and piping and instrumentation diagrams, showing arrangement of piping, valves, controls, and accessory equipment furnished</td>
<td>With RFP</td>
<td>60</td>
</tr>
<tr>
<td>Equipment outline drawings including size, type, and locations of connections by others</td>
<td>With RFP</td>
<td>45</td>
</tr>
<tr>
<td>3-D Model of all equipment</td>
<td>With equipment outline drawings</td>
<td></td>
</tr>
<tr>
<td>Manufacturer’s specifications and catalog data for all equipment and instruments.</td>
<td>With equipment outline drawings</td>
<td></td>
</tr>
<tr>
<td>Equipment List including quantities, descriptions, and part numbers.</td>
<td>With equipment outline drawings</td>
<td></td>
</tr>
<tr>
<td>Section 00 43 33 – Bidder Data and Information</td>
<td>---</td>
<td>With RFP</td>
</tr>
<tr>
<td>Equipment fuel and lubrication specification sheets</td>
<td>---</td>
<td>With RFP</td>
</tr>
<tr>
<td>Installation and erection drawings for equipment furnished</td>
<td>60</td>
<td>90</td>
</tr>
<tr>
<td>Installation Design Review</td>
<td></td>
<td>20 days after received from Engineer</td>
</tr>
<tr>
<td>Recommended spare parts list with prices for turbine generator set, include separate cost for major overhaul.</td>
<td>---</td>
<td>With RFP</td>
</tr>
<tr>
<td>Field installed insulation requirements and details</td>
<td>60</td>
<td>90</td>
</tr>
<tr>
<td>Requirements for sizing and design of connection piping</td>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>Certified factory acceptance test data and results</td>
<td></td>
<td>20 days after test</td>
</tr>
<tr>
<td>Welding qualifications and procedures</td>
<td>---</td>
<td>Prior to fabrication</td>
</tr>
<tr>
<td>Quality assurance manual</td>
<td>---</td>
<td>With RFP</td>
</tr>
<tr>
<td>Drawing of temporary closure devices and field removal procedures</td>
<td>---</td>
<td>60</td>
</tr>
<tr>
<td>Operation and maintenance manual</td>
<td>180 days prior to equipment arriving on Site</td>
<td>90 days prior to equipment arriving on Site</td>
</tr>
<tr>
<td>Description</td>
<td>Preliminary</td>
<td>Certified</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
<td>-------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Maximum allowable connection forces and moments or design envelopes for equipment. These shall be in accordance with ASME B31.1</td>
<td>---</td>
<td>60</td>
</tr>
<tr>
<td>Thermal or other movements to connections by others or allowed by other equipment on equipment of this package</td>
<td>---</td>
<td>60</td>
</tr>
<tr>
<td>Statement guaranteeing maximum time between telephone request for service and arrival of service personnel on site at Owner's facility in Fairbanks, Alaska</td>
<td>---</td>
<td>With RFP</td>
</tr>
<tr>
<td>Scheduled Maintenance Program</td>
<td>--</td>
<td>With RFP</td>
</tr>
<tr>
<td>Noise analysis of system</td>
<td>45</td>
<td>75</td>
</tr>
<tr>
<td>Material Safety Data Sheets</td>
<td>With RFP</td>
<td>90</td>
</tr>
<tr>
<td>List of Training Programs</td>
<td>With RFP</td>
<td>--</td>
</tr>
<tr>
<td>List of Supplier Options</td>
<td>With RFP</td>
<td>--</td>
</tr>
<tr>
<td>Condenser Performance Curves</td>
<td>With RFP</td>
<td>--</td>
</tr>
<tr>
<td>Component List (Shipping)</td>
<td>--</td>
<td>180</td>
</tr>
<tr>
<td>Condenser Diagrammatic Tube Sheet</td>
<td>With RFP</td>
<td></td>
</tr>
<tr>
<td>General Welding Procedures</td>
<td>--</td>
<td>Prior to fabrication</td>
</tr>
<tr>
<td>Tube Expansion Procedure</td>
<td>--</td>
<td>Prior to fabrication</td>
</tr>
<tr>
<td>Paint Application Procedure</td>
<td>--</td>
<td>Prior to fabrication</td>
</tr>
<tr>
<td>Performance curves covering following range of variable above or below specified guaranteed capacity:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.) 60, 80 and 100% of design heat load and at 80F, 60F, 40F, 0F, -10F, and -60F.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.) Cooling range +/-20% from design case (thermal load)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**STRUCTURAL INFORMATION:**

- Air cooled condenser and surface condenser unit weight and center of gravity.  
  - With RFP  
  - 20
- Provide unbalanced forces at normal operating speed.  
  - With RFP  
  - 20
- Recommendations for air cooled condenser and surface condenser foundation design.  
  - With RFP  
  - 20
- Requirements for attaching equipment to foundation or supports, giving size, number, bolt material specification, projection, and location of anchor bolts and leveling plates.  
  - 20
  - 40
- Load information (magnitude and location) for equipment and ducts supported from building structural steel.  
  - 20
  - 40

**ELECTRICAL AND INSTRUMENTATION INFORMATION:**

- For each motor: Identification Tag and description, Application (service), type, horsepower, frame, speed, voltage, number of phases, frequency, full load amperes, full load efficiency, service factor, and manufacturer and model number, installation information, outline drawing, detailed packing and shipping list, shipping notification.  
  - 30
  - 60
- 1-line drawings and load list.  
  - 60
  - 90
- 3-line, schematic and logic diagrams  
  - 60
  - 90
- Supplier’s standard cabling practices  
  - 60
  - 90
### SCHEDULE

<table>
<thead>
<tr>
<th>Description</th>
<th>Calendar Days after NTP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wiring, termination, and functional and interconnecting wiring diagrams including information on conductors.</td>
<td>Preliminary: 60  Certified: 90</td>
</tr>
<tr>
<td>Cable Schedule</td>
<td>Preliminary: 60  Certified: 90</td>
</tr>
<tr>
<td>Instrument List including setpoints and alarm limits, Instrument locations and suggested installation details</td>
<td>Preliminary: 60  Certified: 90</td>
</tr>
<tr>
<td>Turbine and generator control cabinet layouts and operator station details</td>
<td>Preliminary: 60  Certified: 90</td>
</tr>
<tr>
<td>Input/output (I/O) list for air cooled condenser and condenser control systems</td>
<td>Preliminary: 60  Certified: 90</td>
</tr>
<tr>
<td>I/O list of points available from air cooled condenser and condenser control system over digital interface link with DCS including internal PLC registers for each point</td>
<td>Preliminary: 60  Certified: 90</td>
</tr>
<tr>
<td>Typical Graphical Screens</td>
<td>Preliminary: 30  Certified: 60</td>
</tr>
</tbody>
</table>

**PART 2**  **PRODUCTS**  
NOT USED

**PART 3**  **EXECUTION**  
NOT USED

END OF SECTION
PART 1    GENERAL

1.01 SUBMITTAL PROCEDURES

A. Deliver submittals to Buyer in electronic format via the projects' Aconex Document Control System.
   1. Permissions to the Aconex system will be established upon award of contract.
   2. Submittal contact information will be established upon award of contract.

B. Deliver submittals to Buyer in electronic format when required by Specification Sections.

C. Submittals shall be in English language.

D. Weights, measures, and units shall be English units (I-P)

E. SI metric values may also be included in parenthesis.

F. Symbols and drawings shall conform to ANSI Y32.2/IEEE 315/CSA Z99.

1.02 SELLER RESPONSIBILITIES

A. Review submittals prior to submission.

B. Determine and verify:
   1. Measurements.
   2. Construction criteria.
   3. Catalog numbers and similar data.
   4. Conformance to Specifications.

C. Coordinate each submittal with other submittals and with requirements of Contract Documents.

D. Notify Engineer in writing, at time of submission, of any deviations in submittals from requirements of
   Contract Documents. Any such deviations permitted by Engineer will require modifications of Contract
   Documents.

E. Provide space on Submittal Drawings for Seller and Engineer stamps.

F. When Submittal Drawings are revised for resubmission, identify all changes made since previous
   submission.

G. Submittals containing language imposing duties on others (such as verification of dimensions or supply of
   related information) inconsistent with contract language shall be null and void.

H. Submittals shall not be used as media for inquiries for information or for verification of information that must
   be supplied by others to Seller. Inquiries or verification of information shall be made by separate Seller
   submittal using Request for Information (RFI) process.

I. Begin no fabrication of Goods requiring submittal review until return of submittals by Engineer with stamp,
   as either "Reviewed", "Reviewed as Noted", or "Reviewed as Noted-Resubmit."

J. Seller shall not ship any shop tested equipment, per the Inspection and Test Plan, until shop test results
   have been submitted to the Engineer for review and have been returned as "Reviewed" or "Reviewed as
   Noted."

K. Distribute copies of reviewed submittals that carry reviewer stamp as either "Reviewed" or "Reviewed as
   Noted" as appropriate. Instruct parties to promptly report any inability to comply with requirements.

L. Submittals not requested will not be recognized or processed.

1.03 ENGINEER DUTIES
A. Review required submittals with reasonable promptness and in accordance with Paragraph 1.04.I of this Section, only for general conformance to design concept of Project and compliance with information given in Contract Documents. Review shall not extend to means, methods, sequences, techniques, or procedures of construction or to safety precautions or program incident thereto. Review of a separate item as such will not indicate approval of assembly in which item functions.

B. Affix stamp and initials or signature, and indicate requirements for resubmittal, or review of submittal. Engineer's action on submittals is classified as follows:
1. Reviewed: Submittal has been reviewed and appears to be in conformance to design concept of Project and Contract Documents. Seller may proceed with fabrication of work in submittal.
2. Reviewed As Noted: Submittal has been reviewed and appears to be in conformance to design concept of Project and Contract Documents, except as noted by reviewer. Seller may proceed with fabrication of work in submittal with modifications and corrections as indicated by reviewer.
3. Reviewed As Noted-Resubmit: Submittal has been reviewed and appears to be in conformance to design concept of Project and Contract Documents, except as noted by reviewer. Seller may proceed with fabrication of work in submittal with modifications and corrections as indicated by reviewer. Seller shall make any corrections indicated by reviewer and resubmit for review.
4. Resubmit: Submittal has been reviewed and appears not to be in conformance to design concept of Project or with Contract Documents. Seller shall not proceed with fabrication of work in submittal, but instead shall make any corrections required by reviewer and resubmit for review.
5. Returned without Review: Submittal is being returned without having been reviewed because: 1) not required by Contract Documents; 2) grossly incomplete; 3) indicates no attempt at conformance to Contract Documents; 4) cannot be reproduced; 5) lacks Seller's completed vendor submittal approval stamp, where appropriate; or 6) lacks design professional's seal when required by law or Contract Documents. If submittal is required by Contract Documents, Seller shall not proceed with Work as detailed in submittal, but instead shall correct defects and resubmit for review.
6. For Information Only: Submittal has not been reviewed but is being retained for informational purposes only.
7. Void: Submittal is voided because it is no longer required or has been superseded by another submittal.

C. Return electronic copy of submittals to Seller.

D. Review of submittals shall not relieve Seller from responsibility for any variation from Contract Documents unless Seller has, in writing, called Engineer's attention to such variation at time of submission, and Engineer has given written concurrence pursuant to Contract Documents to specific variation, nor shall any concurrence by Engineer or other reviewer relieve Seller from responsibility for errors or omissions in submittals.

1.04 DOCUMENT SUBMITTAL REQUIREMENTS

A. Submit for review for limited purpose of checking for conformance to information given and design concept expressed in Contract Documents. Distribute in accordance with this Section.

B. Submit documents for review in accordance with the dates established in Section 01 32 19 – Submittals Schedule.

C. Make submittals promptly in accordance with approved schedule, and in such sequence as to cause no delay in Work or in work of other Sellers.

D. Present in clear and thorough manner, complete with respect to dimensions, design criteria, materials of construction, and like information to enable review of information as required.

E. Details shall be identified by reference to sheet and detail, schedule or room numbers shown on Drawings.

F. Indicate special utility and electrical characteristics, utility connection requirements, and location of utility outlets for service for functional equipment and appliances.

G. Equipment which is identified on Contract Documents with tag number or name shall be identified on submitted Drawing with same tag.
H. Schedule submittals to expedite Project. Coordinate submission of related items.

I. For each submittal for review, allow ten (10) working days excluding delivery time to and from Seller (if applicable).

J. Identify variations from Contract Documents and product or system limitations which may be detrimental to successful performance of completed Work.

K. Documents shall be submitted in electronic format.
   1. Submit electronic copy via the projects Aconex document control system.
   2. All documents shall be submitted in *.PDF format unless specifically requested in another format by the Buyer.
   3. Electronic submittal shall be suitable for reproduction in black and white.
   5. For drawings consisting of multiple sheets. Each sheet of a drawing shall be submitted as a separate electronic file.
   6. File naming requirements
      a. Drawings: File names should consist of the Seller's drawing number.
      b. Documents: File names should consist of the Seller's document number.
      c. In the event that a document does not have a document number (example: a manufacturers cut sheet), the file name shall consist of the document name. The underscore character (_) shall be used in lieu of a space between words.

L. Submitted documents shall contain:
   1. Names of:
      a. Seller.
      b. Supplier.
      c. Manufacturer.
   2. Document identification number (Drawing number, Document number)
   3. Document revision number (documents that were not developed specifically for this project, such as catalog cut sheets and standard O&M manuals, are excepted)
   4. Identification of product, with Specification section number and article number.
   5. Dimensional information, if applicable.
   6. Relation to adjacent or critical features of Work or materials.
   7. Applicable standards, such as ASTM or Federal Specification numbers.
   9. Identification of revisions on resubmittals through the use of revision clouds (back-circles).
   10. An 8" x 3" blank space for Seller and reviewer stamps.
   11. Indication of Seller's approval, initialized or signed, with wording substantially as follows:
       "Seller represents to Buyer and Engineeer that Seller has either determined and verified all quantities, dimensions, field construction criteria, materials, catalog numbers, and similar data, or assumes full responsibility for doing so and has reviewed or coordinated each submittal with requirements of Work and Contract Documents."

   12. If Contract Documents include performance specifications stating required results which can be verified as meeting stipulated criteria, so that further design by Seller prior to fabrication is necessary, Submittal depicting such design must be prepared under seal of professional engineer registered as a Professional Engineer of the appropriate discipline in the State of Alaska. Submittal shall be signed and sealed in accordance with applicable regulations and with following certification statement:
       "I hereby certify that this engineering document was prepared by me or under my direct personal supervision, that I am a duly registered professional engineer under laws of state of Alaska and I accept responsibility for adequacy of this document to meet criteria stipulated in Contract Documents."
M. Product Data:
1. Mark each copy to identify applicable products, models, options, and other data. Supplement manufacturers’ standard data to provide information specific to this Project.
2. Indicate product utility and electrical characteristics, utility connection requirements, and location of utility outlets for service for functional equipment and appliances.

N. Design data:
1. Submit for Engineer’s knowledge as contract administrator or for Buyer.
2. Submit for information for limited purpose of assessing conformance with information given and design concept expressed in Contract Documents.

O. Data sheets:
1. Data sheets may require information not known until Seller’s engineering is complete. Furnish estimated values based on good engineering judgment. Estimated values shall be identified by placement of “(est.)” next to value.
2. Data Sheets shall be updated and resubmitted by Seller once final values are known.
3. Do not leave items blank or labeled “To Be Determined” or “Later.”
4. Do not submit manufacturer Product Data instead of completed data sheets.

P. Test reports:
1. Submit for Engineer’s knowledge as contract administrator or for Buyer.
2. Submit test reports for information for limited purpose of assessing conformance with information given and design concept expressed in Contract Documents.
3. Reference Paragraph 1.02.J for required review status prior to release of tested equipment for shipment.

Q. Certificates:
1. When specified in individual specification sections, submit certification by manufacturer, installation/application subcontractor.
2. Indicate material or product conforms to or exceeds specified requirements. Submit supporting reference data, affidavits, and certifications as appropriate.
3. Certificates may be recent or previous test results on material or product, but must be acceptable to reviewer.

R. Manufacturer’s instructions:
1. When specified in individual specification sections, submit printed instructions for delivery, storage, assembly, installation, start-up, adjusting, and finishing, to Engineer for delivery to Buyer in quantities specified for Product Data.
2. Indicate special procedures, perimeter conditions requiring special attention, and special environmental criteria required for application or installation.

S. Manufacturer’s field reports:
1. Submit weekly reports from Sellers field personnel within five (5) working days of the end of the observation period for Buyers and Engineers information.
2. Submit for information for limited purpose of assessing conformance with information given and design concept expressed in Contract Documents.
3. Reference Section 01 43 33 – Manufacturer’s Field Services for required report content.

T. Erection drawings:
1. Submit for limited purpose of assessing conformance with information given and design concept expressed in Contract Documents.
2. Data indicating inappropriate or unacceptable Work may be subject to action by Engineer or Buyer.

U. Operations and maintenance manuals:
1. Designate in construction schedule, or in separate coordinated schedule, dates for submission and dates that reviewed operations and maintenance manuals will be needed.
2. Operations and maintenance manuals shall be presented in clear and thorough manner, complete with respect to dimensions, design criteria, materials of construction, and like information to enable reviewer to review information as required. Details shall be identified by reference to sheet and detail shown on Drawings.
3. Reference Section 01 78 23 – Operating and Maintenance for format and required content.
1.05 COMMENT REVIEW MEETINGS

A. It shall be a goal of the entire project team to minimize the number of document resubmittals that are required to complete the work.

B. A web based teleconference shall be held subsequent to the return of each submittal package that contains comments if deemed necessary by Seller, Buyer and/or Engineer. The Seller and the Engineer will discuss and resolve any comments or questions provided on the reviewed drawings that may need additional clarification or discussion.

C. It is strongly recommended that the Seller seek to resolve all comments provided on the reviewed copy of a drawing prior to resubmitting the drawing in question.

D. Submittal packages that do not contain any substantial comments will not require a meeting.

E. The requirement for a teleconference regarding a particular package containing minor comments may be waived by mutual consent.

1.06 RESUBMISSION REQUIREMENTS

A. Make any corrections or changes in submittals required by Engineer and resubmit until stamped as either "Reviewed," "Reviewed as Noted," or "For Information Only."

B. Text and depictions changed on Submittal shall be revision triangles.

C. Engineer will assume that portions of Submittal not indicated have not been changed by Seller from previous submission.

D. Provide update revision number, a brief description of changes, and date in document revision block.

E. Engineer comments made to documents that are marked as “Reviewed as Noted” shall be incorporated into the document as appropriate. Seller will advise Engineer regarding comments not incorporated. Resubmittal of corrected documents is not required until the document is resubmitted as a final record copy.

F. All documents submitted for review and returned as “Reviewed," "Reviewed as Noted," or “For Information Only.” Shall have an electronic stamp applied that shall indicate in some way that the drawing is final once all corrections have been made, if any. Stamped drawings shall then be resubmitted for the project record. Acceptable wording for stamps includes, but is not limited to: “Final” or “Record Copy.”

1.07 SUBMITTAL TRANSMITTAL FORM PROCEDURES

A. Submittals shall be accompanied by a completed Submittal Transmittal form, located in Section 00 62 11. An electronic version of transmittal form is available and will be provided by Engineer.

B. Sequentially number transmittal form. Revise submittals with original number and sequential alphabetic suffix. Note: Revised submittals occur due to an error or omission on the original submittal. Resubmittals are not “revised submittals” and therefore shall have their own unique transmittal number.

C. Prior to submittal, complete information under heading “Seller's Transmittal.”

D. Engineer will complete information under “Reviewer's Action.”

E. Identify project title, location, and number and contract title and number.

F. Identify preparer name and, submittal number.

G. A brief description under "Title" should clearly identify specific application of equipment or material covered by Submittal, utilizing where possible same title used in Drawings and Specifications.
H. Identify Specification Section number.

I. Apply Seller's stamp, signed or initialed certifying that review, approval, verification of products required, field dimensions, adjacent construction work, and coordination of information is in accordance with requirements of Contract Documents.

1.08 NONCONFORMANCES

A. The Buyer reserves the right to return any or all submittals and documents that do not conform to the requirements stated herein.

B. Returned submittals and documents will be given a status of “Returned without Review” as described in Paragraph 1.03.B.5.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

NOT USED

END OF SECTION

1) J. Solan
2) R. Hernandez
PART 1  GENERAL

1.01  SOURCE QUALITY CONTROL

A. Seller shall give Buyer, Engineer, or a Buyer-designated third party access to products for inspection upon request, including products provided by sub-vendors, so long as the inspection does not impact the schedule of production.

B. Seller shall fully cooperate with inspections.

C. Seller shall coordinate and facilitate inspections of products provided by sub-vendors

D. Inspections shall include manufacturing or shop testing.

1.02  QUALITY CONTROL

A. Monitor quality control over suppliers, manufacturers, products, and services, to produce Work of specified quality.

1. Seller to provide quarterly reports summarizing QA/QC activities in the form of purchased equipment surveillance schedules.

B. Comply with manufacturers' instructions, including each step in sequence.

C. Comply with specified standards as minimum quality for the Work except where more stringent codes or specified requirements indicate higher standards or more precise workmanship.

1.03  TOLERANCE

A. Monitor fabrication tolerance control of products to produce acceptable Work. Do not permit tolerances to accumulate.

1.04  WELDING CERTIFICATES

A. Maintain copies at Sellers facilities for each person, by name, assigned to do field welding of materials installed under this Agreement for review by Buyer.

B. Show on certificates that each person has passed tests specified by AWS.

1.05  TESTING AND INSPECTION SERVICES

A. Buyer will employ and pay for services of an independent firm to perform testing and inspection.

B. The independent firm will perform tests, inspections and other services specified as deemed necessary by the Buyer to provide assurance as to the quality of the product being supplied.

C. Seller shall cooperate with Buyers independent inspection firm; furnish samples of materials, equipment, tools, storage, safe access, and assistance by incidental labor as requested.

1. Seller will collaboratively coordinate the manufacturing schedule with the Buyer to accommodate additional testing. However, Buyers testing to support the agreed upon manufacturing schedule.

D. Testing and employment of testing agency or laboratory shall not relieve Seller of obligation to perform Work in accordance with requirements of Contract Documents.
E. Re-testing or re-inspection required because of nonconformance to specified requirements shall be performed by the same independent firm. Payment for re-testing or re-inspection will be charged to the Seller.

F. Agency responsibilities:
   1. Provide qualified personnel at site. Cooperate with Seller in performance of services.
   2. Perform sampling and testing of products in accordance with specified standards.
   3. Ascertain compliance of materials and mixes with requirements of Contract Documents.
   4. Promptly notify Seller of observed irregularities or non-conformance of Work or products.

G. Agency reports: After each test, Agency will promptly submit report to Seller. When requested, Agency will provide interpretation of test results. Reports will include the following:
   1. Date issued.
   2. Project title and number.
   3. Name of inspector.
   4. Date and time of sampling or inspection.
   5. Identification of product and specifications section.
   6. Location in the Project.
   7. Type of inspection or test.
   8. Date of test.
   9. Results of tests.

H. Limits on testing authority:
   1. Agency or laboratory may not release, revoke, alter, or enlarge on requirements of Contract Documents.
   2. Agency or laboratory may not approve or accept any portion of the Work.
   3. Agency or laboratory may not assume any duties of Seller.
   4. Agency or laboratory has no authority to stop the Work.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

NOT USED

END OF SECTION

1) J. Solan
PART 1  GENERAL

1.01 GENERAL

A. Seller shall give all notices and comply with all local, state, and federal laws, ordinances, building and construction codes, rules, and regulations applicable to Work, including those of the City of Fairbanks, and the State of Alaska. If Seller observes that Specifications or Drawings are at variance therewith, Seller shall give Engineer prompt written notice thereof, and any necessary changes shall be adjusted by appropriate Modification. If Seller performs any Work knowing or having reason to know that it is contrary to such laws, ordinances, rules, and regulations, and without such notice to Engineer, Seller shall bear all costs arising therefrom; however, it shall not be Seller’s primary responsibility to make certain that Specifications and Drawings are in accordance with such laws, ordinances, rules, and regulations.

B. This section identifies the governing design codes and regulatory bodies for this project. It is not intended to be an exhaustive list of all applicable codes, standards, regulations, laws, ordinances, or rules. Seller is ultimately responsible for determining and complying with all regulatory design requirements, regardless of the source.

C. Seller shall comply with all relevant codes, standards, laws, ordinances, and rules including those that are incorporated by reference in the documents listed in Paragraph 1.02 of this section.

1.02 APPLICABLE CODES

<table>
<thead>
<tr>
<th>Association</th>
<th>Number/Acronym</th>
<th>Version</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICC</td>
<td>IBC</td>
<td>2009</td>
<td>International Building Code</td>
</tr>
<tr>
<td>HEI</td>
<td>2012</td>
<td></td>
<td>Standards for Steam Surface Condensers</td>
</tr>
<tr>
<td>HEI</td>
<td>2011</td>
<td></td>
<td>Standards for Air Cooled Condensers</td>
</tr>
<tr>
<td>HEI</td>
<td>2011</td>
<td></td>
<td>Performance for Liquid Ring Vacuum Pumps</td>
</tr>
<tr>
<td>ASME</td>
<td>B31.1</td>
<td>2012</td>
<td>Code for Pressure Piping – Power Piping</td>
</tr>
<tr>
<td>IEEE</td>
<td>NESC</td>
<td>2012</td>
<td>National Electrical Safety Code (Applicable Sections)</td>
</tr>
</tbody>
</table>

1.03 REGULATORY BODIES

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSHA</td>
<td>Occupational Safety and Health Administration</td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental Protection Agency</td>
</tr>
<tr>
<td>ADEC</td>
<td>Alaska Department of Environmental Conservation</td>
</tr>
<tr>
<td>AHJ</td>
<td>University of Alaska Fairbanks</td>
</tr>
</tbody>
</table>

PART 2  PRODUCTS

NOT USED

PART 3  EXECUTION

NOT USED

END OF SECTION
1) J. Solan
2) R. Hernandez
PART 1  GENERAL

1.01 QUALITY ASSURANCE

A. For products or workmanship specified by association, trade, or Federal Standards, comply with requirements of standard, except when more rigid requirements are specified or are required by applicable codes.

B. Conform to reference standard by date of issue current on date for receiving bids, except where a specific date is established by code.

C. When required by individual Specifications Section, obtain copy of standard. Maintain copy at job site during submittals, planning, and progress of specific work, until Substantial Completion.

D. Should specified reference standards conflict with Contract Documents, request clarification from the Engineer before proceeding.

E. Neither the contractual relationships, duties, or responsibilities of the parties in Contract nor those of the Engineer shall be altered from the Contract Documents by mention or inference otherwise in any reference document.

F. Abbreviations used in Drawings and Specifications are as specified in ANSI Y1.1 and IEEE 260.

1.02 SCHEDULE OF REFERENCES

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Name and Address</th>
</tr>
</thead>
</table>
| AA      | Aluminum Association  
          | 900 19th St., NW  
          | Washington, DC 20006  
          | www.aluminum.org |
| AABC    | Associated Air Balance Council  
          | 1518 K St., NW  
          | Washington, DC 20005  
          | www.aabchq.com |
| AAMA    | American Architectural Manufacturers Association  
          | 1827 Walden Office Sq., Suite 104  
          | Schaumburg, IL 60173-4268  
          | www.aamanet.org |
| AASHTO  | American Association of State Highway and Transportation Officials  
          | 444 North Capitol St., NW, Suite 249  
          | Washington, DC 20001  
          | www.aashto.org |
| ABMA    | American Boiler Manufacturers Association  
| ABMA    | American Bearing Manufacturers Association  
          | 1200 19th St., NW, Suite 300  
          | Washington, DC 20036-2422  
          | www.abma-dc.org |
| ACGIH   | American Conference of Governmental Industrial Hygienists  
<pre><code>      | 1330 Kemper Meadow Dr. Suite 600 |
</code></pre>
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Name and Address</th>
</tr>
</thead>
</table>
| ACI     | American Concrete Institute  
P.O. Box 9094  
Farmington Hills, MI 48333  
www.aci-int.org |
| ACIL    | American Council of Independent Laboratories  
1629 K St. NW  
Washington DC 20006  
www.acil.org |
| ADC     | Air Diffusion Council  
104 South Michigan Ave., Suite 1500  
Chicago, IL 60603 |
| ADSC    | The International Association of Foundation Drilling  
9696 Skillman Street, Suite 280  
Dallas, TX 75243  
www.adsc-iafd.com |
| AEIC    | Association of Edison Illuminating Engineers |
| AFS     | American Foundrymen's Society  
Golf and Wolf Rds.  
Des Plaines, IL 60016 |
| AGA     | American Gas Association  
400 N Capitol St. NW  
Washington DC  20001  
www.aga.com |
| AGMA    | American Gear Manufacturers Association  
1500 King St  
Suite 201  
Arlington, VA 22314  
www.agma.org |
| AHA     | American Hardboard Association  
1210 W. Northwest Hwy  
Palatine, IL 60067  
www.hardboard.org |
| AI      | Asphalt Institute  
Research Park Drive  
P.O. Box 14052  
Lexington, KY 40512-4052  
www.asphaltinstitute.org |
| AIChE   | American Institute of Chemical Engineers  
3 Park Ave.  
New York, NY 10016  
www.aiche.org |
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Name and Address</th>
</tr>
</thead>
</table>
| AISC    | American Institute of Steel Construction  
One East Wacker Dr., Suite 3100  
Chicago, IL 60601-2001  
www.aisc.org |
| AISI    | American Iron and Steel Institute  
1101 17th St., NW, Suite 1300  
Washington, DC 20036  
www.steel.org |
| AMCA    | Air Movement and Control Association International, Inc.  
30 W. University Dr.  
Arlington Heights, IL 60004-1893  
www.amca.org |
| ANSI    | American National Standards Institute  
1819 L. Street, N.W.  
Washington, DC 20036  
www.ansi.org |
| API     | American Petroleum Institute  
1220 L St., NW  
Washington, DC 20005-4070  
www.api.org |
| APMO    | International Association of Plumbing and Mechanical Officials  
20001 Walnut Dr. S  
Walnut, CA 91789  
www.iapmo.org |
| AREMA   | American Railway Engineering and Maintenance-of-Way Association  
8201 Corporate Drive, Suite 1125  
Landover, MD 02785-2230  
www.arema.org |
| ARI     | Air-Conditioning and Refrigeration Institute  
4301 Fairfax Dr., Suite 425  
Arlington, VA 22203  
www.ari.org |
| ASA     | Acoustical Society of America  
2 Huntington Quadrangle, Ste.1N01  
Melville, NY 11747-4502 |
| ASCE    | American Society of Civil Engineers  
World Headquarters  
1801 Alexander Graham Bell Dr.  
Reston, VA 20191-4400  
www.asce.org |
<p>| ASHRAE  | American Society of Heating, Refrigerating and Air-Conditioning Engineers |</p>
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Name and Address</th>
</tr>
</thead>
</table>
| ASME    | American Society of Mechanical Engineers  
         | 3 Park Ave.  
         | New York, NY 10016-5990  
         | www.asme.org |
| ASNT    | American Society for Nondestructive Testing |
| ASSE    | 901 Canterbury, Suite A  
         | Westlake, OH 44145  
         | www.asse-plumbing.org |
| ASTM    | American Society for Testing and Materials  
         | 100 Barr Harbor Dr.  
         | West Conshohocken, PA 19428-2959  
         | www.astm.org |
| AWS     | American Welding Society  
         | 550 NW LeJeune Rd.  
         | Miami, FL 33126  
         | www.amweld.org |
| AWWA    | American Water Works Association  
         | 6666 W. Quincy Ave.  
         | Denver, CO 80235  
         | www.awwa.org |
| CBM     | Certified Ballast Manufacturers Association  
         | 355 Lexington Ave., 17th Fl.  
         | New York, NY 10017 |
| CEMA    | Conveyor Equipment Manufacturers Association  
         | 6724 Lone Oak Blvd.  
         | Naples, FL 34109 |
| CISCA   | Ceilings and Interior Systems Construction Association  
         | 1500 Lincoln Hwy, Suite 202  
         | St. Charles, IL 60174  
         | www.cisca.org |
| CISPI   | Cast Iron Soil Pipe Institute  
         | 5959 Shallowford Rd., Suite 419  
         | Chattanooga, TN 37421  
         | www.cispi.org |
| CLFMI   | Chain Link Fence Manufacturers Institute  
         | 9891 Broken Land Pkwy, Suite 300  
         | Columbia, MD 21046  
<pre><code>     | www.chainlinkinfo.org |
</code></pre>
<p>| CMAA    | Crane Manufacturers Association of America |</p>
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Name and Address</th>
</tr>
</thead>
</table>
| CPSC    | Consumer Products Safety Council  
  230 S Dearborn St., Rm 2944  
  Chicago, IL 60604  
  [www cpsc gov](http://www.cpsc.gov) |
| CRI     | Carpet and Rug Institute  
  310 S. Holiday Ave.  
  Dalton, GA 30722-2048  
  [www.carpet-rug.com](http://www.carpet-rug.com) |
| CRSI    | Concrete Reinforcing Steel Institute  
  933 N. Plum Grove Rd.  
  Schaumburg, IL 60173-4758  
  [www.crsi.org](http://www.crsi.org) |
| CTI     | Cooling Technology Institute  
  530 Wells Fargo Drive, Suite 218  
  Houston, TX 77090  
  [www.cti.org](http://www.cti.org) |
| DASMA   | Door and Access Systems Manufacturers Association International  
  1300 Summer Avenue  
  Cleveland, OH 44115-2851  
  [www.dasma.com](http://www.dasma.com) |
| DHI     | The Door and Hardware Institute  
  14150 Newbrook Dr., Suite 200  
  Chantilly, VA 20151  
  [www.dhi.org](http://www.dhi.org) |
| EIA     | Electronic Industries Alliance  
  2500 Wilson Blvd.  
  Arlington, VA 22201  
  [www.eia.org](http://www.eia.org) |
| EJMA    | Expansion Joint Manufacturers Association  
  25 N Broadway  
  Tarrytown, NY 10591 |
| EPRI    | Electric Power Research Institute |
| EPA     | Environmental Protection Agency  
  [www.epa.gov](http://www.epa.gov) |
| FAA     | Federal Aviation Administration  
  [www.faa.gov](http://www.faa.gov) |
| FM      | FM Global  
  Corporate Headquarters.  
  P.O. Box 7500  
  Johnston, RI 02919 |
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Name and Address</th>
</tr>
</thead>
</table>
| GA      | Gypsum Association  
810 First St., NE, Suite 510  
Washington, DC 20002  
www.usg.com  
www.gypsum.org |
| GANA    | Glass Association of North America  
2945 Southwest Wanamaker Dr., Suite A  
Topeka, KS 66614  
www.glasswebsite.com/gana |
| HEI     | Heat Exchange Institute |
| HI      | Hydraulics Institute  
9 Sylvan Way  
Parsippany, NJ 07054-3802 |
| HI      | Hydronics Institute  
Division of Gas Appliance Manufacturers Association  
P. O. Box 218  
35 Russo Pl.  
Berkeley Heights, NJ 07922  
www.gamanet.org |
| HMI     | Hoist Manufacturers Institute |
| HMMA    | Hollow Metal Manufacturers Association  
Division of NAAMM  
8 South Michigan Ave., Suite 1000  
Chicago, IL 60603  
www.naamm.org |
| IAS     | International Approval Services  
U.S. Operations  
8501 E. Pleasant Valley Rd.  
Cleveland, Ohio 44131-5575  
www.approvals.org |
| ICAC    | Institute of Clean Air Companies  
1600 L St. NW Suite 1100  
Washington DC 20036  
www.icac.com |
| ICBO    | International Conference of Building Officials  
5360 Workman Mill Rd.  
Wittier, CA 90601  
www.icbo.org |
| ICC     | International Code Council, Inc.  
5203 Leesburg Pike #708  
Falls Church, VA 22041  
www.intlcode.org |
<p>| ICEA    | Insulated Cable Engineers Association |</p>
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Name and Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. O. Box 440</td>
<td>South Yarmouth, MA 02664</td>
</tr>
<tr>
<td>IEC</td>
<td>International Electro-technical Council</td>
</tr>
<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers 3 Park Ave., 17th Floor New York, NY 10016-5997 <a href="http://www.ieee.org">www.ieee.org</a></td>
</tr>
<tr>
<td>IES</td>
<td>Illuminating Engineering Society of North America 120 Wall Street, 17th Floor New York, NY 10005 <a href="http://www.iesna.org">www.iesna.org</a></td>
</tr>
<tr>
<td>IMI</td>
<td>International Masonry Institute The James Brice House 42 East Street Annapolis, MD 21401</td>
</tr>
<tr>
<td>IGCC</td>
<td>Insulating Glass Certification Council P. O. Box 9 Henderson Harbor, NY 13651</td>
</tr>
<tr>
<td>ILI</td>
<td>Indiana Limestone Institute of America 400 Stone City Bank Building Bedford, IN 47421 <a href="http://www.iliai.com">www.iliai.com</a></td>
</tr>
<tr>
<td>ISA</td>
<td>The Instrumentation, Systems, and Automation Society P.O. Box 3561 67 Alexander Dr. Durham, NC 27702 <a href="http://www.isa.org">www.isa.org</a></td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization Geneva, Switzerland</td>
</tr>
<tr>
<td>MBMA</td>
<td>Metal Building Manufacturers Association 1300 Sumner Ave. Cleveland, OH 44115-2851 <a href="http://www.mbma.com">www.mbma.com</a></td>
</tr>
<tr>
<td>MSS</td>
<td>Manufacturers Standardization Society of the Valve and Fittings Industry 127 Park St., NE Vienna, VA 22180-4602 <a href="http://www.mss-hq.com">www.mss-hq.com</a></td>
</tr>
<tr>
<td>NAAMM</td>
<td>National Association of Architectural Metal Manufacturers</td>
</tr>
<tr>
<td>Acronym</td>
<td>Name and Address</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------</td>
</tr>
<tr>
<td>8 South Michigan Ave., Suite 1000 Chicago, IL 60603 <a href="http://www.naamm.org">www.naamm.org</a></td>
<td>NACE International 1440 South Creek Drive Houston, TX 77084 <a href="http://www.nace.org">www.nace.org</a></td>
</tr>
<tr>
<td>National Concrete Masonry Association 2302 Horse Pen Rd. Herndon, VA 20171-3499 <a href="http://www.ncma.org">www.ncma.org</a></td>
<td>NEBB National Environmental Balancing Bureau 8575 Grovemont Circle Gaithersburg, MD 20877 <a href="http://www.nebb.org">www.nebb.org</a></td>
</tr>
<tr>
<td>National Electrical Contractors Association 3 Bethesda Metro Center, Suite 1100 Bethesda, MD 20814 <a href="http://www.necanet.org">www.necanet.org</a></td>
<td>NEMA National Electrical Manufacturers Association 1300 N 17th St., Suite 1847 Rosslyn, VA 22209 <a href="http://www.nema.org">www.nema.org</a></td>
</tr>
<tr>
<td>International Electrical Testing Association P.O. Box 687 106 Stone St. Morrison, CO 80465 <a href="http://www.netaworld.org">www.netaworld.org</a></td>
<td>NFPA National Fire Protection Association One Batterymarch Park P.O. Box 9101 Quincy, MA 02269-9101 <a href="http://www.nfpa.org">www.nfpa.org</a></td>
</tr>
<tr>
<td>National Fenestration Rating Council 1300 Spring St., Suite 500 Silver Spring, MD 20910 <a href="http://www.nfrc.org">www.nfrc.org</a></td>
<td></td>
</tr>
<tr>
<td>Acronym</td>
<td>Name and Address</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------</td>
</tr>
</tbody>
</table>
| NIBS    | National Institute of Building Sciences  
|         | 1090 Vermont Ave., NW, Suite 700  
|         | Washington, DC 20005-4905  
|         | [www.nibs.org](http://www.nibs.org) |
| NIST    | National Institute of Standards and Technology  
|         | 100 Bureau Dr., MS 2150  
|         | Gaithersburg, MD 20899-2150  
|         | [www.nist.gov](http://www.nist.gov) |
| NLA     | National Lime Association  
|         | 200 North Glebe Rd., Suite 800  
|         | Arlington, VA 22203  
|         | [www.lime.org](http://www.lime.org) |
| NPCA    | National Paint and Coatings Association  
|         | 1500 Rhode Island Ave., NW  
|         | Washington, DC 20005  
|         | [www.paint.org](http://www.paint.org) |
| NRMCA   | National Ready Mixed Concrete Association  
|         | 900 Spring St.  
|         | Silver Spring, MD 20910 |
| NSF     | NSF International  
|         | P.O. Box 130140  
|         | Ann Arbor, MI 48113-0140  
|         | [www.nsf.org](http://www.nsf.org) |
| OSHA    | Occupational Safety and Health Administration  
|         | [www.osha.gov](http://www.osha.gov) |
| PCI     | Precast/Prestressed Concrete Institute  
|         | 209 W. Jackson Blvd.  
|         | Chicago, IL 60606-6938  
|         | [www.pci.org](http://www.pci.org) |
| PDI     | Plumbing and Drainage Institute  
|         | 45 Bristol Dr.  
|         | South Easton, MA 02375  
|         | [http://PDIonline.org](http://PDIonline.org) |
| PFI     | Pipe Fabrication Institute  
|         | 1326 Freeport Road  
|         | Pittsburgh, PA 15238 |
| PTI     | Post Tensioning Institute  
|         | 1717 W. Northern Ave., Suite 114  
|         | Phoenix, AZ 85021  
<p>|         | <a href="http://www.post-tensioning.org">www.post-tensioning.org</a> |
| RCSC    | Research Council on Structural Connections |</p>
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Name and Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMA</td>
<td>Rubber Manufacturers Association</td>
</tr>
</tbody>
</table>
| SAMA    | Scientific Apparatus Makers Association  
1101 16th Street N.W.  
Suite 300  
Washington, DC 20036 |
| SBCCI   | Southern Building Code Congress International  
900 Montclair Rd.  
Birmingham, AL 35213 |
| SDI     | Steel Deck Institute  
P.O. Box 25  
Fox River Grove, IL 60021  
www.sdi.org |
| SDI     | Steel Door Institute  
30200 Detroit Rd.  
Cleveland, OH 44145-1967  
www.steeldoor.org |
| SFC     | State Fire Code |
| SIGMA   | Sealed Insulating Glass Manufacturers Association  
401 N. Michigan Ave.  
Chicago, IL 60611  
www.sigmaonline.org/sigma |
| SJI     | Steel Joist Institute  
3127 10th Ave., North Ext.  
Myrtle Beach, SC 29577-6760  
www.steeljoist.org |
| SMACCNA | Sheet Metal and Air Conditioning Contractors' National Association  
4201 Lafayette Center Dr.  
Chantilly, VA 20151-1209  
www.smacn.org |
| SSPC    | SSPC: The Society for Protective Coatings  
40 24th St., 6th Floor  
Pittsburgh, PA 15222-4656  
www.sspc.org |
| STI     | Steel Tank Institute  
570 Oakwood Rd.  
Lake Zurich, IL 60047  
www.steeltank.com |
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Name and Address</th>
</tr>
</thead>
</table>
| SWI     | Steel Window Institute  
1300 Sumner Ave.  
Cleveland, OH 44115-2851  
www.steelwindows.com |
| SWRI    | Sealant, Waterproofing and Restoration Institute  
2841 Main St.  
Kansas City, MO 64108  
www.swrionline.org |
| TEMA    | Tubular Exchange Manufacturers Association  
25 N Broadway  
Tarrytown, NY 10591 |
| TIMA    | Thermal Insulation Manufacturers Association |
| TPI     | Truss Plate Institute  
583 D’Onofrio Dr., Suite 200  
Madison, WI 53719 |
| UFC     | Uniform Fire Code |
| UL      | Underwriters Laboratories Inc.  
333 Pfingsten Rd.  
Northbrook, IL 60062-2096  
www.ul.com |
| UMC     | Uniform Mechanical Code |
| UPC     | Uniform Plumbing Code |
| WDMA    | Window and Door Manufacturers Association  
1400 E. Touhy Ave., Suite 470  
Des Plaines, IL 60018  
www.nwwda.org |
| WH      | Intertek Testing Services  
Warnock Hersey Listing Services  
3210 American Drive  
Mississauga, Ontario  
Canada L4V 1B3  
www.itsqs.com |

**PART 2  PRODUCTS**

NOT USED

**PART 3  EXECUTION**

NOT USED

END OF SECTION
PART 1  GENERAL

1.01 WELDING REQUIREMENTS

A. Welding shall be performed by qualified welding operators using procedures which have been qualified in accordance with applicable codes and standards, including but not limited to:
   1. ASME B31 Code for Pressure Piping – Power Piping
   2. ASME Boiler and Pressure Vessel Code.
   3. AWS D1.1 and AWS D1.3 Structural WeldingCodes.

1.02 PROCEDURE QUALIFICATION

A. Seller, Subcontractor, or fabricator performing welding under jurisdiction of referenced codes shall be responsible for obtaining and qualifying welding procedures. Structural welding procedures conforming to AWS D1.1 are prequalified as defined in AWS D1.1, Clause 3.

B. Contractor shall maintain records, and make available to Special Inspector when requested, certifying successful completion of procedure qualification tests.

1.03 PERFORMANCE QUALIFICATION

A. Seller, Subcontractor, or fabricator performing welding under jurisdiction of referenced codes shall be responsible for testing and qualifying its welding operators in accordance with applicable codes, using qualified procedures.

B. Welding operator’s qualification as specified in code shall be considered as remaining in effect indefinitely unless welder has not engaged in given process of welding for which welding operator is qualified for period of 6 months.

1.04 SUBMITTALS

A. Except for procedures exempted by AWS D1.1, Clause 3, maintain copies of each welding procedure with certificate demonstrating successful qualification of welding procedures for each welding process performed at Sellers facilities: AWS D1.1 - Form N-1, or ASME QW-483.

B. Prior to execution of any manual shop welding, maintain copies of welder qualification form for each individual performing welding: AWS D1.1 Form N-4 or ASME QW-484.

PART 2  PRODUCTS

NOT USED

PART 3  EXECUTION

NOT USED

END OF SECTION

1) J. Solan
2) R. Hernandez
PART 1  GENERAL

1.01 DEFINITIONS:

A. Erecting Technical Advisor: A technical representative employed directly by the Seller that is experienced in the erection of the structures and field erected equipment included in this contract.

B. Commissioning Technical Advisor: A technical representative that is skilled in the installation, startup, commissioning, troubleshooting, tuning and testing of specific pieces of equipment provided under this contract by the Seller or a subvendor of the Seller. The representative shall be employed directly by the company that supplied the equipment.

1.02 ERECTING TECHNICAL ADVISOR RESPONSIBILITIES

A. Seller shall provide qualified Erecting Technical Advisor(s), as necessary to:
   1. Assist with the inspection and documentation of deliveries of Sellers equipment to site, in cooperation with the Buyer and Installation Contractor. Assist the Installation Contractor and the Buyer with the evaluation of the equipment for damage and help determine missing material against the Bill of Lading and any other documentation provided by the Seller.
   2. Review with installation contractor regarding proper method for unloading, erecting, and installing equipment to assure installation in accordance with manufacturer's instructions.
   3. Confirm that alignment and clearances of equipment are checked and adjusted to allowable tolerances.
   4. Review preliminary installation of equipment and advise Installation Contractor and Buyer of necessary adjustments.
   5. Advise Buyer's operating personnel in operation and maintenance of equipment.

B. Presence of Erecting Technical Advisor will in no way relieve Seller of any responsibility assumed under Agreement.

C. Work and abilities of each Erecting Technical Advisor shall be subject to review of Buyer. Seller shall provide resumes for all Erecting Technical Advisors at least 30 days prior to the arrival of the proposed personnel on site. If Buyer determines that any Erecting Technical Advisor is not properly qualified, Seller shall replace Erecting Technical Advisor upon written notification by Buyer.

D. Seller shall provide continuity in assignment of Erecting Technical Advisor to Work. In the event that a substitution of the Erecting Technical Advisor is made which is not at request of Buyer, substitute's time for "familiarization" shall be at Seller's expense. The transition period between Technical Advisors shall not be less than one (1) week. The transition period for personnel acting as the Sellers primary or lead Erecting Technical Advisor shall not be less than two (2) weeks.

E. If any of Erecting Technical Advisor's time spent at site or if any of his trips to site are required to make corrections to equipment supplied under Agreement resulting from defective design, material or workmanship used in manufacture of equipment, such time and trips will be at Seller's expense and will not be counted against number of working days or trips specified.

1.03 COMMISSIONING TECHNICAL ADVISOR RESPONSIBILITIES

A. Seller provide qualified Commissioning Technical Advisor(s), as necessary to:
   1. Review assembly of equipment.
   2. Inspect equipment after it is installed to confirm that all details of installation are correct and that equipment is prepared for operation in accordance with manufacturer's instructions and recommendations.
   3. Check connections to equipment and confirm equipment has been installed and connected per design.
   4. Advise Buyer's operating personnel in operation and maintenance of equipment.
   5. Assist with the Coordination of startup and commissioning activities with Buyer and Installation Contractor.
   6. Provide review of final alignment and clearance measurements on all rotating or reciprocating equipment.
   7. Review preliminary operation of equipment and necessary adjustments.
8. Inspect completed installation to assure that apparatus is in operating condition, making such detailed checks of equipment installation as are necessary to ascertain that equipment is assembled, installed, aligned, connected, lubricated, and prepared for operation in accordance with manufacturer's instructions and recommendations.

9. Develop detailed startup and commissioning procedures for each piece of major equipment and each system provided by Seller under this contract. Procedures shall follow a logical step-by-step process to validate that all equipment and instrumentation was properly installed and is functioning within established design parameters.

B. Presence of Commissioning Technical Advisor will in no way relieve Seller of any responsibility assumed under Agreement.

C. Work and abilities of Commissioning Technical Advisor shall be subject to review of Buyer. If Buyer determines that any Commissioning Technical Advisor is not properly qualified, Seller shall replace Commissioning Technical Advisor upon written notification by Buyer.

D. Seller shall provide continuity in assignment of Commissioning Technical Advisor to Work. In event substitution of Commissioning Technical Advisor is made which is not at request of Buyer, substitute's time for “familiarization” shall be at Seller's expense. The transition period between Technical Advisors shall not be less than one (1) week. The transition period for personnel acting as the Sellers primary or lead Erecting Technical Advisor shall not be less than two (2) weeks.

E. If any of Commissioning Technical Advisor's time spent at site or if any of his trips to site are required to make corrections to equipment supplied under Agreement resulting from defective design, material or workmanship used in manufacture of equipment, such time and trips will be at Seller's expense and will not be counted against number of working days or trips specified.

PART 2 PRODUCTS

A. Provide quotation for Erecting Technical Advisor and Commissioning Technical Advisor within proposal.

PART 3 EXECUTION

NOT USED

END OF SECTION

1) J. Solan
2) R. Hernandez
PART 1 GENERAL

1.01 SECTION INCLUDES

A. 3-D CAD Model

PART 2 PRODUCTS

2.01 SUBMITTALS

A. 3-D Model
   1. Submit 3-D model files in accordance with Section 01 33 00 – Submittal Procedures and the contract documents.
   2. Files shall be in a format that can be directly imported into Bently Microstation products without loss of fidelity or functionality.

PART 3 EXECUTION

3.01 3-D MODEL REQUIREMENTS

A. Provide 3D CAD model files of structural members, mechanical and electrical equipment, piping systems, pipe supports, cable trays, raceways, conduits, reserved space areas, and any other significant physical obstruction. Model files shall be provided in Microstation V8 XM format (first choice) or Autocad 2008 format or later. Provide a single model (comprised of multiple model files) containing all equipment included in the scope of this Agreement. Refer to the following paragraphs for specific requirements of each component.

B. Structural model files shall be separated by main steel members, secondary steel members and platforms. Identify components based on tier designation. Structural components shall be placed on levels in the models based upon a documented leveling scheme. Platform headroom shall be placed on a separate layer.

C. Mechanical equipment model files shall be separated by systems or by floor elevations. Mechanical equipment shall be placed on levels in the models based upon a documented leveling scheme. Reserved space shall be placed on a separate level.

D. Piping system model files shall be separated by service and insulation and shall be placed on levels in the models based upon a documented leveling scheme. Pipe supports and reserved space shall be placed on a separate level.

E. Identify spaces reserved for hoistways, monorail hoists, hatchways, equipment pull spaces and related areas.

F. Model files shall be geospatially located based upon coordinates provided by the Buyer.

G. Terminal points in 3D models shall be clearly marked with a designator and shall match other documentation provided by the Seller including shop drawings, piping and instrumentation diagrams, connection/termination lists, and other similar documents.

H. Clash detection procedures shall be agreed upon by all parties prior to Contract award. Seller shall document the agreed upon procedures and shall submit them to the Buyer in accordance with Section 01 33 00 – Submittal Procedures.

END OF SECTION
PART 1    GENERAL

1.01 APPLICABILITY

A. This section applies to products purchased by the Seller from subvendors.

B. The requirements of Paragraphs 1.04 shall apply to products directly manufactured by the Seller and products purchased by the Seller from subvendors while these products are being stored at the Sellers facility prior to shipment to the project site.

1.02 SUBVENDOR PRODUCTS

A. Provide products of qualified manufacturers suitable for intended use. Provide products of each type by a single manufacturer where ever possible, unless specified otherwise.

B. All equipment, structural steel, and structural steel fabrication must be supplied and/or performed by a manufacturing/fabrication entity located in North America or Western Europe. This clause does not apply to equipment supplied by the Seller or a wholly owned subsidiary of the Seller.

C. All products shall be in new and undamaged condition.

D. Provide interchangeable components of the same manufacturer for components being replaced.

1.03 SUBVENDOR PRODUCT DELIVERY REQUIREMENTS

A. Transport and handle products in accordance with manufacturer's instructions.

B. Promptly inspect shipments to ensure that products comply with requirements, quantities are correct, and products are undamaged.

C. Provide equipment and personnel to handle products by methods to prevent soiling, disfigurement, or damage.

1.04 RECEIVING, UNLOADING AND STORING

A. Provide physical protection for products placed in storage.
   1. Store and maintain subvendor products after receipt until loaded for transport to site. Such storage and maintenance shall be in accordance with manufacturer's recommendations and requirements of these Specifications.
   2. All stored products shall be stored in a weatherproof building as required below or when required due to environmental conditions.
   3. Products stored outside shall be supported above ground and shall be covered with canvas or other heavy-duty sheeting. Cover shall be securely fastened and shall be replaced if torn or otherwise damaged during storage period.
   4. Electrical equipment or equipment with any electrical components stored outdoors shall be supported at least 12" above ground.
   5. Motors:
      a. Store in dry, warm place (minimum 50ºF).
      b. Space heaters shall be connected upon receipt on site and maintained. Space heaters shall not be connected utilizing extension cords. Use of multi conductor cable only.
      c. Rotate motors over 20 hp 90º each month or as directed by manufacturer.
      d. Perform a mega-ohm meter test on each medium voltage motor winding to frame utilizing a 10kV mega-ohm meter. Perform test each month and record motor serial number, test values, confirmation of space heaters operational, and signature of tester.
      e. Provide Owner with written test reports that this requirement is met when requested.
6. Desiccant shall be maintained between cover and motor frames on motors. Provide desiccant of type permitting visual determination of condition of desiccant. Replace desiccant when it becomes ineffective.

7. Desiccant shall be provided to protect the internals of all sealed steel cylinders, particularly pressure vessels. Inspect desiccant in accordance with manufacturer's instructions in order to verify the desiccant's effectiveness.

8. Following items shall be stored in weatherproof building complete with bins for storage of small pieces of equipment. Heat to a minimum of 50ºF (10ºC).
   a. Electronic instruments and cabinets.
   b. Electrical equipment with general-purpose enclosures.
   c. Insulation materials.
   d. Rotating equipment.
   e. Miscellaneous electronic equipment, gaskets, and small, machined parts.
   f. Instruments and controls.

B. Inspect stored products weekly. Renew protective coatings and desiccants as necessary to preserve fitness of equipment.

C. Provide materials, equipment, and labor required for such storage and maintenance. Seller shall be accountable for any deterioration of materials or equipment occasioned by improper storage or maintenance, and shall recondition, repair, or replace any such materials or equipment without addition cost to Buyer.

1.05 PRODUCTS LIST

A. Submit to Engineer a complete list of major products which are proposed for installation in accordance with the submittal schedule set forth in Section 01 32 19 and Section 01 33 00 - Submittals.

B. Tabulate products by Specification section number and title.

C. For products specified only by reference standards, list for each such product:
   1. Name and address of manufacturer.
   2. Trade name.
   3. Model or catalog designation.
   4. Manufacturer's data:
      a. Reference standards.
      b. Performance test data.

1.06 PRODUCT OPTIONS

A. For products specified only by reference standard, select product meeting that standard, by any manufacturer.

B. For products specified by naming several products or manufacturers, select any one of products and manufacturers named which complies with Specifications.

C. For products specified by naming one or more products or manufacturers and stating "or equal," submit request as for substitutions for any product or manufacturer which is not specifically named in accordance with Section 01 25 13.

D. For products specified by naming only one product and manufacturer, there is no option and no substitution will be allowed.

E. Whenever Specifications call for item by manufacturer's name and type and additional features of item are specifically required by Specifications, additional features specified shall be provided whether or not they are normally included in standard manufacturer's item listed.
PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

NOT USED

END OF SECTION

1) J. Solan
2) R. Hernandez
<table>
<thead>
<tr>
<th>Section</th>
<th>Group</th>
<th>Equipment</th>
<th>Equipment Suppliers</th>
<th>Country</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condensing</td>
<td>All</td>
<td>Any equipment or product</td>
<td>Bidder or wholly owned subsidiary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>480V MCC</td>
<td>480V MCC</td>
<td>Allen Bradley</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>480V MCC</td>
<td>480V MCC</td>
<td>Cutler-Hammer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>480V MCC</td>
<td>480V MCC</td>
<td>General Electric</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>480V MCC</td>
<td>480V MCC</td>
<td>Siemens</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>480V MCC</td>
<td>480V MCC</td>
<td>Square D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Air Filters- Compressed Air</td>
<td>Air Filters- Compressed Air</td>
<td>Hankinson</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Air Filters- Instrument (&amp; Regulators)</td>
<td>Air Filters- Instrument (&amp; Regulators)</td>
<td>Fisher</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Air Filters- Instrument (&amp; Regulators)</td>
<td>Air Filters- Instrument (&amp; Regulators)</td>
<td>Norgren</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Air Filters- Instrument (&amp; Regulators)</td>
<td>Air Filters- Instrument (&amp; Regulators)</td>
<td>Wilkerson</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Coatings</td>
<td>Coatings</td>
<td>Ameron</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Coatings</td>
<td>Coatings</td>
<td>Carboline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Coatings</td>
<td>Coatings</td>
<td>Devoe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Coatings</td>
<td>Coatings</td>
<td>International</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Coatings</td>
<td>Coatings</td>
<td>Jolan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Coatings</td>
<td>Coatings</td>
<td>Keeler &amp; Long</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Coatings</td>
<td>Coatings</td>
<td>PPG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Coatings</td>
<td>Coatings</td>
<td>Sherwin Williams</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Coatings</td>
<td>Coatings</td>
<td>Sigme</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Coatings</td>
<td>Coatings</td>
<td>Tenemec</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Code Pipe Fab</td>
<td>Code Pipe Fab</td>
<td>Bendtec</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Code Pipe Fab</td>
<td>Code Pipe Fab</td>
<td>Boccard</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Code Pipe Fab</td>
<td>Code Pipe Fab</td>
<td>IPS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Code Pipe Fab</td>
<td>Code Pipe Fab</td>
<td>J.F. Ahern</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Code Pipe Fab</td>
<td>Code Pipe Fab</td>
<td>Kelgor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Code Pipe Fab</td>
<td>Code Pipe Fab</td>
<td>Scott</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Code Pipe Fab</td>
<td>Code Pipe Fab</td>
<td>SCPIC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Code Pipe Fab</td>
<td>Code Pipe Fab</td>
<td>Shaw</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Code Pipe Fab</td>
<td>Code Pipe Fab</td>
<td>Sunco</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Code Pipe Fab</td>
<td>Code Pipe Fab</td>
<td>Team</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Code Pipe Fab</td>
<td>Code Pipe Fab</td>
<td>TMRP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Control Panels</td>
<td>Control Panels</td>
<td>Control Engineering Company</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Control Panels</td>
<td>Control Panels</td>
<td>Hoffman Engineering Company</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Control Panels</td>
<td>Control Panels</td>
<td>Rittal</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Dampers</td>
<td>Dampers</td>
<td>Advanced Valve Design</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Dampers</td>
<td>Dampers</td>
<td>Bachman Dampjoint Inc.</td>
<td>CANADA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Dampers</td>
<td>Dampers</td>
<td>Bachman USA</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Dampers</td>
<td>Dampers</td>
<td>Barron Ind.</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Dampers</td>
<td>Dampers</td>
<td>Control Equip. Co.</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Dampers</td>
<td>Dampers</td>
<td>Damper Design Inc.</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Dampers</td>
<td>Dampers</td>
<td>Effox Inc.</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Dampers</td>
<td>Dampers</td>
<td>Flexton</td>
<td>CANADA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Dampers</td>
<td>Dampers</td>
<td>Fox Equipment</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Dampers</td>
<td>Dampers</td>
<td>Fritsch Power &amp; Processing Services</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Dampers</td>
<td>Dampers</td>
<td>Mader</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Dampers</td>
<td>Dampers</td>
<td>TLT Babcock</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Dampers</td>
<td>Dampers</td>
<td>Wahlo Metroflex</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Drives – Variable Speed, 600V and Below</td>
<td>Drives – Variable Speed, 600V and Below</td>
<td>ABB</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Drives – Variable Speed, 600V and Below</td>
<td>Drives – Variable Speed, 600V and Below</td>
<td>Allen Bradley</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Drives – Variable Speed, 600V and Below</td>
<td>Drives – Variable Speed, 600V and Below</td>
<td>Yaskawa</td>
<td>Japan</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Duct and Flue Slide Plates (Sliding Bearing Plates)</td>
<td>Duct and Flue Slide Plates (Sliding Bearing Plates)</td>
<td>American Bearings</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Duct and Flue Slide Plates (Sliding Bearing Plates)</td>
<td>Duct and Flue Slide Plates (Sliding Bearing Plates)</td>
<td>Amscot</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Duct and Flue Slide Plates (Sliding Bearing Plates)</td>
<td>Duct and Flue Slide Plates (Sliding Bearing Plates)</td>
<td>Merriman, Inc.</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Duct and Flue Slide Plates (Sliding Bearing Plates)</td>
<td>Duct and Flue Slide Plates (Sliding Bearing Plates)</td>
<td>R.M. Engineered Products</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Elements- Flow, Averaging Pitot Tubes</td>
<td>Elements- Flow, Averaging Pitot Tubes</td>
<td>Rosemount (Dieterich Standard)</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Expansion Joints (Non-Metal)</td>
<td>Expansion Joints (Non-Metal)</td>
<td>A&amp;A Material</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Expansion Joints (Non-Metal)</td>
<td>Expansion Joints (Non-Metal)</td>
<td>Bachmann Dampjoint</td>
<td>USA</td>
<td></td>
</tr>
</tbody>
</table>
University of Alaska - Combined Heat and Power Plant Replacement Project

3418.01 63 00 - Approved Subcontractors and Suppliers List

Note: Buyer approval of supplier/subcontractor required for any component not specifically called out on this list

<table>
<thead>
<tr>
<th>Section</th>
<th>Group</th>
<th>Equipment</th>
<th>Equipment Suppliers</th>
<th>Country</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condensing</td>
<td>Expansion Joints</td>
<td>(Non-Metal)</td>
<td>Bachmann Industries, Inc.</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Expansion Joints</td>
<td>(Non-Metal)</td>
<td>Dekomte</td>
<td>GERMANY</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Expansion Joints</td>
<td>(Non-Metal)</td>
<td>Effox</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Expansion Joints</td>
<td>(Non-Metal)</td>
<td>Frenzelit</td>
<td>GERMANY</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Expansion Joints</td>
<td>(Non-Metal)</td>
<td>General Rubber Corp.</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Expansion Joints</td>
<td>(Non-Metal)</td>
<td>Industrial Air Flow Dynamics</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Expansion Joints</td>
<td>(Non-Metal)</td>
<td>KE-Burgmann</td>
<td>GERMANY</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Expansion Joints</td>
<td>(Non-Metal)</td>
<td>Nichias</td>
<td>GERMANY</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Expansion Joints</td>
<td>(Non-Metal)</td>
<td>Papco Industries</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Expansion Joints</td>
<td>(Non-Metal)</td>
<td>Pathway (Senior Flexonics)</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Expansion Joints</td>
<td>(Non-Metal)</td>
<td>U.S. Bellows, Inc.</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Expansion Joints</td>
<td>(Non-Metal)</td>
<td>Wahloco Metroflex</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Fuse</td>
<td></td>
<td>Bussman</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Fuse</td>
<td></td>
<td>Bussman or Littel (for Power inlet:</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Safety)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Gearboxes</td>
<td></td>
<td>Rexnord / Faulk</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Gearboxes</td>
<td></td>
<td>Siemens / Flender</td>
<td>Germany</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Gearboxes</td>
<td></td>
<td>GE O&amp;G / Lufkin</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Gearboxes</td>
<td></td>
<td>Voith</td>
<td>Germany</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Gearboxes</td>
<td></td>
<td>Allen Gears</td>
<td>UK</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Gearboxes</td>
<td></td>
<td>Renk - Maag</td>
<td>Switzerland</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Heat Tracing- Electrical</td>
<td></td>
<td>Chromalox</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Heat Tracing- Electrical</td>
<td></td>
<td>Raychem</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Heat Tracing- Electrical</td>
<td></td>
<td>Thermon</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Heat Tracing- Electrical</td>
<td></td>
<td>Tyco</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Instrument Valve Manifolds</td>
<td></td>
<td>Anderson Greenwood Company</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Instrument Valve Manifolds</td>
<td></td>
<td>Emerson</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Instrument Valve Manifolds</td>
<td></td>
<td>PGI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Instrument Valve Manifolds</td>
<td></td>
<td>Rosemount</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Instrument Valve Manifolds</td>
<td></td>
<td>Swagelok</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Integral Valve Position Indicators</td>
<td></td>
<td>Automax</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Integral Valve Position Indicators</td>
<td></td>
<td>Bettiswitch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Integral Valve Position Indicators</td>
<td></td>
<td>Stonel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Integral Valve Position Indicators</td>
<td></td>
<td>Triac</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Integral Valve Position Indicators</td>
<td></td>
<td>Westlock</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Motors</td>
<td></td>
<td>US Electrical Motors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Motors- Low Voltage</td>
<td></td>
<td>ABB</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Motors- Low Voltage</td>
<td></td>
<td>General Electric</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Motors- Low Voltage</td>
<td></td>
<td>Hitachi</td>
<td>Japan</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Motors- Low Voltage</td>
<td></td>
<td>Reliance</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Motors- Low Voltage</td>
<td></td>
<td>Siemens</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Motors- Low Voltage</td>
<td></td>
<td>TECO Westinghouse</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Motors- Low Voltage</td>
<td></td>
<td>Toshiba Mitsubishi- Electric</td>
<td>Japan</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Motors- Low Voltage</td>
<td></td>
<td>WEG</td>
<td>BRAZIL</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Motors- Medium Voltage</td>
<td></td>
<td>ABB</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Motors- Medium Voltage</td>
<td></td>
<td>General Electric</td>
<td>BRAZIL</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Motors- Medium Voltage</td>
<td></td>
<td>Hitachi</td>
<td>JAPAN</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Motors- Medium Voltage</td>
<td></td>
<td>Hyundai</td>
<td>Korea</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Motors- Medium Voltage</td>
<td></td>
<td>Reliance</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Motors- Medium Voltage</td>
<td></td>
<td>Siemens</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Motors- Medium Voltage</td>
<td></td>
<td>TECO/Westinghouse</td>
<td>USA/TAIWAN</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Motors- Medium Voltage</td>
<td></td>
<td>Toshiba</td>
<td>JAPAN</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Motors- Medium Voltage</td>
<td></td>
<td>WEG</td>
<td>BRAZIL</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pipe Hangers and Support</td>
<td></td>
<td>Anvil International (Grinnell)</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pipe Hangers and Support</td>
<td></td>
<td>Atlas Ideal Metals</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pipe Hangers and Support</td>
<td></td>
<td>Basic Engineers</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pipe Hangers and Support</td>
<td></td>
<td>Bergen Power Pipe Supports</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pipe Hangers and Support</td>
<td></td>
<td>Binder</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pipe Hangers and Support</td>
<td></td>
<td>Lisega</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pipe Hangers and Support</td>
<td></td>
<td>Mitsubishi Steel Mfg. Co., Ltd.</td>
<td>JAPAN</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pipe Hangers and Support</td>
<td></td>
<td>Mueller Flow Control</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pipe Hangers and Support</td>
<td></td>
<td>PHS Industries</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pipe Hangers and Support</td>
<td></td>
<td>Pipe Support Ltd.</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Section</td>
<td>Group Equipment</td>
<td>Equipment Suppliers</td>
<td>Country</td>
<td>Notes</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>-----------------</td>
<td>---------------------</td>
<td>---------</td>
<td>-------</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pipe Hangers and Support</td>
<td>Piping Technology</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pipe Hangers and Support</td>
<td>Sanway Tekki</td>
<td>JAPAN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pipe Hangers and Support</td>
<td>SHAW</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pipe Hangers and Support</td>
<td>Yamashita Seisakusyo</td>
<td>JAPAN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pipe Supports (Spring)</td>
<td>Anvil International (Grinnell)</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pipe Supports (Spring)</td>
<td>Basic Engineers</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pipe Supports (Spring)</td>
<td>Bergen Power</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pipe Supports (Spring)</td>
<td>Lisega</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pipe Supports (Spring)</td>
<td>Piping Technologies</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Piping- Fabrication (Metal)</td>
<td>Bendtect Inc.</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Piping- Fabrication (Metal)</td>
<td>DMI</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Piping- Fabrication (Metal)</td>
<td>Globe Mechanical</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Piping- Fabrication (Metal)</td>
<td>JF Ahern</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Piping- Fabrication (Metal)</td>
<td>Shaw Group, Inc.</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Piping- Fabrication (Metal)</td>
<td>Team Industries</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Piping- Fabrication (Metal)</td>
<td>TURNER INDUSTRIES</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Process Heaters</td>
<td>Chromalox</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Process Heaters</td>
<td>Gaumer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Process Heaters</td>
<td>Watlow</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pumps- Vacuum</td>
<td>Gardner Denver Nash</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pumps- Vacuum</td>
<td>Vooner</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pumps- Vacuum</td>
<td>Friatec</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pumps- Vacuum</td>
<td>Dekker</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pumps- Vacuum</td>
<td>Lyco Wausau</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pumps- Vacuum</td>
<td>Wintek</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Pumps- Vacuum</td>
<td>Nitex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Relays - General Purpose</td>
<td>Allen Bradley</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Relays - General Purpose</td>
<td>Cutler-Hammer</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Relays - General Purpose</td>
<td>General Electric</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Relays - General Purpose</td>
<td>Potter-Brumfield</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Relays- Auxiliary Control</td>
<td>Allen Bradley</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Relays- Auxiliary Control</td>
<td>Diversified Electronics</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Relays- Auxiliary Control</td>
<td>General Electric</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Relays- Auxiliary Control</td>
<td>Potter Brumfield</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Relays- Auxiliary Control</td>
<td>Square D</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Relays- Auxiliary Control</td>
<td>Westinghouse</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Silencers (Safety Valves)</td>
<td>BEPM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Silencers (Safety Valves)</td>
<td>Burgess Manning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Silencers (Safety Valves)</td>
<td>CCI/Fluid Kinetics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Silencers (Safety Valves)</td>
<td>Maxim</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Silencers (Safety Valves)</td>
<td>Quietflo</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Terminal Blocks</td>
<td>Allen Bradley</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Terminal Blocks</td>
<td>Marathon</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Terminal Blocks</td>
<td>Marathon</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Terminal Blocks</td>
<td>Phoenix</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Transducers (electrical)</td>
<td>GE</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Transducers (electrical)</td>
<td>Moore Industries</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Transducers (electrical)</td>
<td>Rochester Instruments</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Transducers (electrical)</td>
<td>Scientific Columbus</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Transducers (electrical)</td>
<td>Transdata</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Transducers- Frequency</td>
<td>Scientific Columbus</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Transducers, Watt</td>
<td>Scientific Columbus</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Tube Fittings</td>
<td>Parker</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Tube Fittings</td>
<td>Swagelok</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Tube Fittings</td>
<td>Whitey</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Ball</td>
<td>Apollo</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Ball</td>
<td>Copeland</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Ball</td>
<td>Mogas</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Ball</td>
<td>Neles- Jamesbury</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Ball</td>
<td>Parker</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Ball</td>
<td>Powell</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Ball</td>
<td>Severe Service Technologies c/o Power Tech</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Buyer approval of supplier/subcontractor required for any component not specifically called out on this list.
Note: Buyer approval of supplier/subcontractor required for any component not specifically called out on this list

<table>
<thead>
<tr>
<th>Section</th>
<th>Group</th>
<th>Equipment</th>
<th>Equipment Suppliers</th>
<th>Country</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condensing</td>
<td>Valves - Ball</td>
<td>Tyco Valve Co.</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Ball</td>
<td>Valve Technologies</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Ball</td>
<td>Velan</td>
<td>CAN/USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Ball</td>
<td>Watts</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Bronze</td>
<td>Fugikin</td>
<td>JAPAN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Bronze</td>
<td>Hitachi</td>
<td>JAPAN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Bronze</td>
<td>Jenkins</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Bronze</td>
<td>Kitz</td>
<td>JAPAN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Bronze</td>
<td>Lunkenheimer</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Butterfly</td>
<td>Anchor/Darling (Flowserve)</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Butterfly</td>
<td>Bray</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Butterfly</td>
<td>Centerline</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Butterfly</td>
<td>DeZurik/Copes Vulcan</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Butterfly</td>
<td>Dressler/Masonelian</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Butterfly</td>
<td>Durco</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Butterfly</td>
<td>Flowserve</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Butterfly</td>
<td>Keystone</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Butterfly</td>
<td>KSB-Amri</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Butterfly</td>
<td>Metso/Jamesbury</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Butterfly</td>
<td>Pratt</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Butterfly</td>
<td>Rodney Hunt</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Butterfly</td>
<td>Tyco</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Butterfly</td>
<td>Zwick</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Butterfly - High Performance</td>
<td>DeZurik/Copes Vulcan, Inc.</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Butterfly - High Performance</td>
<td>Henry Pratt Company</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Butterfly - High Performance</td>
<td>Keystone</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Butterfly - High Performance</td>
<td>Rodney Hunt</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Butterfly - High Performance</td>
<td>Tyco Valves &amp; Controls</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Butterfly - High Performance</td>
<td>Amri</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Butterfly - High Performance</td>
<td>DeZurik/Copes Vulcan, Inc.</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Butterfly - High Performance</td>
<td>Henry Pratt Company</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Butterfly - High Performance</td>
<td>Tyco Valves &amp; Controls</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Butterfly - High Performance</td>
<td>Zwick</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Cast Steel</td>
<td>Anchor Darling</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Cast Steel</td>
<td>Atwood &amp; Morrill</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Cast Steel</td>
<td>Bonney Forge</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Cast Steel</td>
<td>Dewrance</td>
<td>UK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Cast Steel</td>
<td>Flowserve</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Cast Steel</td>
<td>Pacific/Crane</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Cast Steel</td>
<td>Powell</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Cast Steel</td>
<td>Rockwell Edwards</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Cast Steel</td>
<td>Tyco</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Cast Steel</td>
<td>Valve Technologies</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Cast Steel</td>
<td>Velan</td>
<td>USA/ CAN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Cast Steel</td>
<td>Weir</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Control and Regulators</td>
<td>Masonelian</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Forged Steel</td>
<td>Anderson Greenwood Company</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Forged Steel</td>
<td>Bonney Forge</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Forged Steel</td>
<td>Conval</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Forged Steel</td>
<td>Crane Pacific</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Forged Steel</td>
<td>Dresser Hancock</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Forged Steel</td>
<td>Edwards (Flowserve)</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Forged Steel</td>
<td>Mogas</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Forged Steel</td>
<td>Valve Technologies</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Forged Steel</td>
<td>Velan</td>
<td>USA/ CAN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Forged Steel</td>
<td>Vogt (Flowserve)</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Forged Steel</td>
<td>Whitey</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - Forged Steel</td>
<td>Yarway</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - High Pressure Cast Steel</td>
<td>Anchor Darling</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - High Pressure Cast Steel</td>
<td>Bonney Forge</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves - High Pressure Cast Steel</td>
<td>Crane Pacific Valves</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Section</td>
<td>Group</td>
<td>Equipment</td>
<td>Equipment Suppliers</td>
<td>Country</td>
<td>Notes</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------------</td>
<td>------------------------------------</td>
<td>----------------------------------------------</td>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- High Pressure Cast Steel</td>
<td>Departance</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- High Pressure Cast Steel</td>
<td>Edward/Vogt (Flowserve)</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- High Pressure Cast Steel</td>
<td>Flowserve Edward</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- High Pressure Cast Steel</td>
<td>Karatsu Valve Co., Ltd.</td>
<td>JAPAN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- High Pressure Cast Steel</td>
<td>Pacific/Crane</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- High Pressure Cast Steel</td>
<td>Powell</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- High Pressure Cast Steel</td>
<td>Tyco Valve Co.</td>
<td>USA/Canada</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- High Pressure Cast Steel</td>
<td>Tyco Valves &amp; Controls</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- High Pressure Cast Steel</td>
<td>Utsue Valves Co., Ltd.</td>
<td>JAPAN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- High Pressure Cast Steel</td>
<td>Valvetechologies</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- High Pressure Cast Steel</td>
<td>Velan</td>
<td>CAN/USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- High Pressure Cast Steel</td>
<td>Velan Valve Corporation</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- High Pressure Cast Steel</td>
<td>Weir Valves &amp; Controls</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Insert Type and Other Stop &amp; Check</td>
<td>Crane</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Insert Type and Other Stop &amp; Check</td>
<td>Duo Check</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Insert Type and Other Stop &amp; Check</td>
<td>Karatsu Valve Co. Ltd.</td>
<td>JAPAN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Insert Type and Other Stop &amp; Check</td>
<td>Keystone/Anderson Greenwood</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Insert Type and Other Stop &amp; Check</td>
<td>Marlin</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Insert Type and Other Stop &amp; Check</td>
<td>Power &amp; Process (Technocheck)</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Insert Type and Other Stop &amp; Check</td>
<td>Tyco Valve Co.</td>
<td>USA/Canada</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Insert Type and Other Stop &amp; Check</td>
<td>Velan</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Insert Type and Other Stop &amp; Check</td>
<td>Weir</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Instrument</td>
<td>Anderson Greenwood Company</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Instrument</td>
<td>Swagelok</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Instrument</td>
<td>Whitey</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Plug</td>
<td>DeZurik</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Plug</td>
<td>Duriron/Durco</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Plug</td>
<td>Keystone</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Plug</td>
<td>Newcon</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Plug</td>
<td>Nordstrom/Tufline (Division of Xomox)</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Plug</td>
<td>Velan</td>
<td>USA/Canada</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Safety Relief</td>
<td>Lonegran (Tycro)</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Safety Relief</td>
<td>Tyco (Crosby)</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Safety Relief</td>
<td>Vickers (Eaton)</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Severe Service Ball</td>
<td>Control Components Inc - Sulzer</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Severe Service Ball</td>
<td>Crane</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Severe Service Ball</td>
<td>Fisher Control</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Severe Service Ball</td>
<td>Flowserve</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Severe Service Ball</td>
<td>Mogas</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Severe Service Ball</td>
<td>SPX Process Equipment (Copes Vulcan)</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Severe Service Ball</td>
<td>Valve Technologies</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Severe Service Ball</td>
<td>Velan</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Severe Service Ball</td>
<td>Varanay</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Solenoid</td>
<td>ASCO</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Solenoid</td>
<td>Stonel</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Tilting Disc Check</td>
<td>Anchor/Darling (Flowserve)</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Tilting Disc Check</td>
<td>Atwood &amp; Morrill</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Tilting Disc Check</td>
<td>Edwards</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valve Actuators - Electric</td>
<td>EIM (Emerson)</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valve Actuators - Electric</td>
<td>Harold Beck &amp; Sons, Inc.</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valve Actuators - Electric</td>
<td>Limitorque</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Damper Actuators - Electric</td>
<td>Beck</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Damper Actuators - Electric</td>
<td>Jordan</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Detectors (Hopper Level)</td>
<td>Drexelbrook</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Section</td>
<td>Group</td>
<td>Equipment</td>
<td>Equipment Suppliers</td>
<td>Country</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>-------</td>
<td>-----------</td>
<td>---------------------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Detectors (Hopper Level)</td>
<td>Endress and Hauser</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Flow Tubes - Precision Metering Run</td>
<td>Rosemount</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Flow Tubes - Precision Metering Run</td>
<td>Vickery Simms</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Flowmeters- DP (Steam)</td>
<td>McCrometer</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Flowmeters- Magnetic (Water)</td>
<td>Rosemount</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Flowmeters- Magnetic (Water)</td>
<td>Endress &amp; Hauser</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Flowmeters- Positive Displacement</td>
<td>Badger Meter</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Flowmeters- Positive Displacement</td>
<td>Neptune</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Flowmeters- Rotameters</td>
<td>Brooks Instruments</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Flowmeters- Rotameters</td>
<td>Fisher &amp; Porter</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Flowmeters- Mass Flow (Air / Gas)</td>
<td>Rosemount</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Flowmeters- Mass Flow (Air / Gas)</td>
<td>FCI</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Flowmeters- Turbine</td>
<td>Badger Meter</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Flowmeters- Ultrasonic</td>
<td>Siemens</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Flowmeters- Ultrasonic</td>
<td>Fisher &amp; Porter</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Flowmeters- Vortex</td>
<td>Rosemount</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Flowmeters with Flow Controller- Combustion Air</td>
<td>AMC Power</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Flowmeters with Flow Transmitter - Fluidizing Air</td>
<td>AMC Power</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Gauges- Level</td>
<td>Clark Reliance</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Gauges- Level</td>
<td>Magnetrol</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Gauges- Level</td>
<td>K-Tek</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Gauges- Level, Bubbler</td>
<td>Uehling</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Gauges- Pressure</td>
<td>3D/Sierra Precision</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Gauges- Pressure</td>
<td>US Gauge/Ametek</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Gauges- Pressure</td>
<td>Wika</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Gauges- Strain / Load Cell</td>
<td>Ramsey</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Gauges- Temperature</td>
<td>3D/Sierra Precision</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Gauges- Temperature</td>
<td>US Gauge/Ametek</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Gauges- Temperature</td>
<td>Wika</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Indicators (RF admittance tank, tower, sump level)</td>
<td>Rosemount</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Level Assemblies (Column, Transmitter, Probe, Switches)</td>
<td>Clark Reliance</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Level Assemblies (Column, Transmitter, Probe, Switches)</td>
<td>Magnetrol</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Level Assemblies (Column, Transmitter, Probe, Switches)</td>
<td>K-Tek</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches - Differential Pressure</td>
<td>Ashcroft</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches - Differential Pressure</td>
<td>Barton</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches - Differential Pressure</td>
<td>Static O-Ring</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches - Pressure</td>
<td>Ashcroft</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches - Pressure</td>
<td>Barton</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches - Pressure</td>
<td>Static O-Ring</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches - Temperature</td>
<td>Ashcroft</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches - Temperature</td>
<td>Barton</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches - Temperature</td>
<td>Static O-Ring</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches - Capacitance or Vibratory Indicato</td>
<td>Bindicator</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches- Capacitance or Vibratory</td>
<td>Endress &amp; hauser</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches- Level</td>
<td>Drexelbrook</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches- Level</td>
<td>K-Tek</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches- Level</td>
<td>Magnetrol</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches- Level, Conductivity</td>
<td>Solartron</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches- Level, Conductivity</td>
<td>Penberthy</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches- Level, Displacer</td>
<td>Magnetrol</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches- Level, Displacer</td>
<td>Mercoid</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches- Level, Float</td>
<td>ITT</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches- Level, Float</td>
<td>K-Tek</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches- Level, Float</td>
<td>Magnetrol</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches- Level, Ultrasonic</td>
<td>Magnetrol</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches- Level, Ultrasonic</td>
<td>Milltronics</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches- Limit</td>
<td>Allen Bradley</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches- Limit</td>
<td>Microswitch</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Section</td>
<td>Group</td>
<td>Equipment</td>
<td>Equipment Suppliers</td>
<td>Country</td>
<td>Notes</td>
</tr>
<tr>
<td>---------</td>
<td>-------</td>
<td>----------------------------</td>
<td>--------------------------------------</td>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches- Limit</td>
<td>Namco (Snap Lock)</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches- Limit</td>
<td>Honeywell</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches- Limit</td>
<td>Topworx</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches- Tilt Probe</td>
<td>Drexelbrook</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Switches- Tilt Probe</td>
<td>Ramsey</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Thermocouples &amp; RTDs</td>
<td>JMS Southeast</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Thermocouples &amp; RTDs</td>
<td>Pyromation</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Thermocouples &amp; RTDs</td>
<td>Wika</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Thermocouples &amp; RTDs</td>
<td>Thermo Electric</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Thermowells</td>
<td>Thermo Electric</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Thermowells</td>
<td>JMS Southeast</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Thermowells</td>
<td>Pyromation</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Thermowells</td>
<td>Wika</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Transmitters- Level (Radar Contact / Non-contact)</td>
<td>Rosemount</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Transmitters- Level (Radar Contact / Non-contact)</td>
<td>Endress &amp; Hauser</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Transmitters- Level (Ultrasonic)</td>
<td>Rosemount</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Transmitters- Level (Ultrasonic)</td>
<td>Endress &amp; Hauser</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Transmitters- Pressure</td>
<td>Rosemount</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Transmitters- Pressure</td>
<td>Endress &amp; Hauser</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Transmitters- Pressure/DP</td>
<td>Rosemount</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Transmitters- Pressure/DP</td>
<td>Endress &amp; Hauser</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Transmitters- Temperature</td>
<td>Rosemount</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Transmitters- Temperature</td>
<td>Endress &amp; Hauser</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Control (pneumatic)</td>
<td>CCI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Control (pneumatic)</td>
<td>Fisher Controls (Emerson Process Management)</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Control (pneumatic)</td>
<td>Masoneilan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Regulators</td>
<td>Fisher Controls (Emerson Process Management)</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Regulators</td>
<td>Spence</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Regulators</td>
<td>Cashco</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Safety Relief</td>
<td>Consolidated- Dresser Ind.</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Safety Relief</td>
<td>Farris Engineering</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Valves- Solenoid</td>
<td>ASCO</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Vibration Monitor</td>
<td>Allen Bradley</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condensing</td>
<td>Vibration Sensor (Probes &amp; Transducers)</td>
<td>Bently Nevada</td>
<td>USA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Buyer approval of supplier/subcontractor required for any component not specifically called out on this list.
PART 1  GENERAL

1.01 OPERATING AND MAINTENANCE DATA REQUIREMENTS

A. Operating and maintenance data shall be in English language.

B. Compile product data and related information appropriate for Buyer’s maintenance and operation personnel for products furnished under Agreement.

C. Prepare operating and maintenance data as specified in this section and as referenced in other pertinent sections of Specifications.

D. Instruct Owner’s personnel in maintenance of products and in operation of equipment and systems.

1.02 QUALITY ASSURANCE

A. Preparation of data shall be done by personnel:
   a. Trained and experienced in maintenance and operation of described products.
   b. Familiar with requirements of this section.
   c. Skilled as technical writers to extent required to communicate essential data.
   d. Skilled as draftsmen competent to prepare required drawings.

1.03 FORM OF SUBMITTALS

A. Prepare data in form of an instructional manual for use by Owner's personnel.

B. Submit three (3) copies of complete manual in final form

C. Format:
   a. Sheet size: 8-1/2" x 11" or 11"x17" folded to 8-1/2" x 11".
   b. Paper: 20 lb minimum, white, for typed pages.
   c. Text: Manufacturer's printed data, or neatly typewritten.
   d. Drawings:
      1) Provide reinforced punched binder tab, bind in with text.
      2) Larger size drawings shall be folded to 8-1/2” x 11”, and inserted into pockets.
   e. Provide fly-leaf for each separate product, or each piece of operating equipment.
   f. Provide typed description of product, and major component parts of equipment.
   g. Provide indexed tabs.
   h. Binders:
      1) Commercial quality, slant “D” type, 3-ring binders with durable and cleanable plastic covers.
      i. Maximum capacity: 75% of manufacturers stated capacity
      j. When multiple binders (volumes) are used, correlate data into related consistent groupings.
      k. Each volume shall contain a copy of the master table of contents indicating the contents of all volumes.

D. Reference the O&M cover diagram at the end of this section for required content of information on cover and recommended formatting.

E. Provide linked, indexed, and bookmarked electronic copy of the manual(s) in PDF format. Duplicate organization and format of the hard copy of the manual(s) to the greatest extent possible.

1.04 CONTENT OF MANUAL

A. Neatly typewritten table of contents for each volume, arranged in systematic order.

B. Product data:
1. List of each product required to be included, indexed to content of volume.
2. List, with each product, name, address, and telephone number of:
   a. Subsupplier (if applicable).
   b. Maintenance contractor, as appropriate.
   c. Identify area of responsibility of each.
3. Local or regional source of supply for parts and replacement and list of recommended spare parts.
   a. Local shall be interpreted as being located inside the State of Alaska, and should be utilized prior to regional or other locales when possible.
   b. Regional shall be interpreted as being located in the Northwestern areas of the US and Canadian Provinces, and should be utilized prior other locales when possible.
4. Identify each product by product name and other identifying symbols as set forth in Contract Documents, including nameplate information and order and part numbers for each item of equipment furnished.
5. Include an O&M Datasheet for each piece of equipment (datasheet provided by Owner upon request).
6. Include only those sheets which are pertinent to specific product.
7. Annotate each sheet to:
   a. Clearly identify specific product or part installed.
   b. Clearly identify data applicable to installation.
   c. Delete references to inapplicable information.

C. Drawings:
   a. Supplement product data with Drawings as necessary to clearly illustrate:
      1) Relations of component parts of equipment and systems.
      2) Control and flow diagrams.
   b. Provide exploded parts diagrams where available from manufacturer.
   c. Coordinate Drawings with information in Project record documents to assure correct illustration of completed installation.
   d. Provide as- manufactured submittal drawings from equipment manufacturer.
   e. Do not use Project record documents as maintenance Drawings.

D. Written text, as required to supplement product data for particular installation.
   a. Organize in consistent format under separate headings for different procedures.
   b. Contents, for each unit of equipment and system, as appropriate:
   c. Description of unit and component parts:
      1) Function, normal operating characteristics, and limiting conditions.
      2) Performance curves, engineering data, and tests.
      3) Complete nomenclature and commercial number of replaceable parts.
   d. Operating procedures:
      1) Startup, break-in, routine, and normal operating instructions.
      2) Regulation, control, stopping, shutdown, and emergency instructions.
      3) Summer and winter operating instructions.
      4) Special operating instructions including testing and adjustment.
   e. Maintenance procedures:
      1) Routine operations and preventative maintenance.
      2) Guide to "trouble-shooting."
      3) Disassembly, repair, and reassembly.
      4) Alignment, adjusting, and checking.
   f. Servicing and lubrication schedule: List of lubricants required.
   g. Manufacturer's printed operating and maintenance instructions.
   h. Description of sequence of operation by control manufacturer.
   i. Original manufacturer's parts list, illustrations, assembly drawings, and diagrams required for maintenance.
      1) Items recommended to be stocked as spare parts.
   j. As-installed control diagrams by controls manufacturer.
   k. Project lists, including but not limited to:
      1) Equipment list
      2) Valve list
3) Pipeline list
4) Instrument list.
l. List of original manufacturer's spare parts, manufacturer's current prices, and recommended quantities to be maintained in storage.
m. Other data as required under pertinent sections of Specifications.
n. Content, for each electrical and electronic system, as appropriate.
o. Description of system and component parts:
   1) Function, normal operating characteristics, and limiting conditions.
   2) Performance curves, engineering data, and tests.
   3) Complete nomenclature and commercial number of replacement parts.
p. Circuit directories of panelboards:
   1) Electrical service.
   2) Controls.
   3) Communications.
q. As-installed color-coded wiring diagrams.
r. Operating procedures:
   1) Routine and normal operating instructions.
   2) Sequences required.
   3) Special operating instructions.
s. Maintenance procedures:
   1) Routine operations.
   2) Guide to "trouble-shooting."
   3) Disassembly, repair, and assembly.
   4) Adjustment and checking.
t. Manufacturer's printed operating and maintenance instructions.
u. List of original manufacturer's spare parts, manufacturer's current prices, and recommended quantities to be maintained in storage.
v. Other data as required under pertinent sections of Specifications.

E. Prepare and include additional data when need for such data becomes apparent during instruction of Owner's personnel.

F. Additional requirements for operating and maintenance data: Respective sections of Specifications.

G. Revise the applicable portions of the manuals to incorporate any significant changes made in the field. Provide updates with, or prior to, release of any bonds.

1.05 SUBMITTAL SCHEDULE

A. Submit the following in accordance with the dates provided in the Section 01 32 19 - Submittal Schedule.

   1. Submit a single copy of the proposed formats and outlines of contents in electronic format. Buyer will review and return with comments.

   2. Submit a single copy of a complete preliminary draft in electronic format. Buyer will review and return with comments.

   3. Submit specified copies of manual in final form and with all Buyer comments resolved.

1.06 DEMONSTRATION AND INSTRUCTION OF OWNER'S PERSONNEL

A. Demonstrate operation and maintenance of products to Owner's personnel prior to date of final acceptance.

B. Buyer and Seller shall agree on final instruction durations and locations no less than 3 months before instruction is scheduled to commence. Discrepancies in scope or cost shall be resolved via the Change Order process.
C. Demonstrate Project equipment and provide instruction in a classroom environment. Demonstrations and instruction shall be performed by a qualified manufacturer's representative who is knowledgeable about the Project.

D. Where required by individual specifications, provide a manufacturer's representative to demonstrate operation of auxiliary equipment and to provide instruction in a classroom environment. Seller shall maintain responsibility for the quality of instruction provided by representatives of its subvendors.

E. Work and abilities of each instructor shall be subject to review of Buyer. Seller shall provide resumes for all instructors at least 30 days prior to the arrival of the proposed personnel on site. If Buyer determines that any instructor is not properly qualified, Seller shall replace instructor upon written notification by Buyer.

F. For equipment or systems requiring seasonal operation, perform demonstration for other season within 6 months.

G. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with Owner's personnel in detail to explain all aspects of operation and maintenance.

H. Advise start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment on site at an agreed upon time prior to final acceptance.

I. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

NOT USED

1) J. Solan
1. Imprinting shall be in Arial font.
2. Spine printing shall be 12-point.
3. Cover printing shall be in point sizes indicated.
* If more than one volume is necessary, imprint cover with volume numbers.
PART 1  GENERAL

1.01  SPECIAL TOOLS

A. Contractor shall provide any special tools, jigs, fixtures, and lifting tackle which are necessary for assembly, erection, operation, maintenance, and repair of equipment.

B. Special tools and devices are those design, purpose, and use of which are peculiar to equipment furnished and which are not available from normal wholesale or retail outlets. Standard general purpose tools are not included in this requirement.

C. Contractor shall provide neat and substantial metal tool box with hinged cover and lifting handles or metal cabinet with hinged door and prominently mark box or cabinet "TOOLS FOR ___________." for each set of tools furnished.*

PART 2  PRODUCTS

NOT USED

PART 3  EXECUTION

NOT USED

1) J. Solan

END OF SECTION
PART 1 GENERAL

1.01 SECTION INCLUDES

A. Site conditions.

B. Design criteria.

1.02 SITE CONDITIONS

A. Location: 802 Alumni Drive, Fairbanks, Alaska 99775.

B. Approximate Coordinates: 64° 51.235'N, 147° 49.155'W

C. Elevation: MSL +437.8 feet

1.03 GENERAL DESIGN CRITERIA

A. Building code: Design shall comply with 2009 International Building Code.

B. Steel structures: Design in accordance with applicable provisions of AISC “Specifications for Structural Steel Buildings”, March 9, 2005. Steel structures shall be designed as special concentrically braced frames.

C. Seismic design:
   1. Occupancy Category of Building and Other Structures: IV.
   2. Occupancy Importance Factor: 1.5.
   3. Component Importance Factor for components containing steam, hazardous material, or flammable material: 1.50.
   4. Site Class: C.
   5. Seismic Design Category: D.
   6. Response Spectrum: Table C-2 and Figure C-22 of Exhibit A - Geotechnical Engineering Report.

D. Wind loads:
   1. ASCE 7-05.
   2. Building Category: IV
   3. Importance Factor: 1.15.
   4. Basic Wind Speed: 90 mph.
   5. Exposure: C.
   6. Topographic factor, Kzt: 1.0
   7. Gust effect factor, G: 0.85

E. Snow loads:
   1. ASCE 7-05.
   2. Importance factor, I: 1.20.
   3. Ground snow load: 60 psf.
   4. Exposure Factor, Ce: 0.9.
   5. Thermal Factor, Ct: 1.0.

F. Live loads:
   1. In design of elevated platforms, the following specified floor design live loads are minimums. Where equipment is located on a platform, the structure shall be designed for the larger of the equipment weight or the displaced specified platform live load.
   2. Elevated Platforms:
      (1) Stairways and grating platforms: 100 psf.
3. Roof:
   (1) Snow load: not less than 50 psf. Snow drift to be accounted for per roof layout details.
   (2) Wind uplift.
4. Roving non-accumulating loads:
   (1) Appropriate roving non-accumulating point loads shall be used on steel beams to account for concentration of hanging loads to individual beams that exceed the area hanging load allowance. Use 2 kip minimum.

G. Vibration control:
1. Design structural members to resist impact and dynamic loads imposed by equipment.
2. Design structural members subject to fatigue loading in accordance with AISC requirements.
3. If vibrations, which are objectionable in opinion of Owner, occur during operation of equipment, provide additional stiffening of vibrating members or replace members to satisfaction of Owner as required.
4. Isolate structures supporting vibration-sensitive equipment as required by equipment manufacturer.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

NOT USED

END OF SECTION

1) K. Koch
2)
PART 1  GENERAL

1.01  PURPOSE

A.  NOTE TO BIDDERS: With the exception of condensing system operational, performance, and reliability requirements, this section should be considered preliminary. Final test procedures will be negotiated after notice of intent to award.

B.  The requirements presented in this section shall establish the basis of design and required thermal and operational performance for all equipment provided under this Contract while being operated as a single complete system. Unless otherwise noted in the individual equipment sections, the Seller shall determine the basis of design and required performance of individual pieces of equipment such that the requirements of this section are met during normal operation.

C.  Seller shall provide a detailed write-up explaining the operation of the ACC for freeze protection down to the extreme temperature listed in Section 00 43 33 that encompasses the load ranges provided in Paragraph 1.03 A.

D.  All operating conditions and thermal performance guarantees are contained in Section 00 43 33 – Proposed Products Form. All point value guarantees shall be based on steady load conditions.

E.  Conditions of system inputs provided by the Buyer are located in Paragraph 1.04 of this Section. The information provided shall form the basis from which the Seller shall develop the proposed guarantees.

1.02  BASIS OF DESIGN AND PERFORMANCE

A.  Design condensing system, including ACC, surface condenser and associated equipment included in this Contract to operate at the guaranteed operating values for the guaranteed operating conditions can be found in the Guarantees Section 00 43 33.

B.  The condensing system performance guarantees identified in Section 00 43 33 shall be based upon the use of circulating water quality and steam turbine exhaust conditions as identified in this Section, as well as Sections 00 43 33, 48 11 16, and 48 12 17.

C.  The equipment shall be capable of operating at any point over the entire load range of the steam turbine and under any ambient conditions.

1.03  OPERATIONAL REQUIREMENTS

A.  Operational Range: 10% to 100% of maximum turbine exhaust energy as defined below
1.  Maximum Turbine Exhaust Energy: As defined in the Guarantees included in Section 00 43 33.
2.  Minimum Continuous Load: 10% of maximum turbine exhaust energy.

B.  Meet the following operational requirements over the entire operational range of the steam turbine.
1.  Design ACC to maintain turbine exhaust pressure of 10 inches Hg at an ambient temperature of 93°F without the use of the surface condenser.
2.  Design ACC to maintain turbine exhaust pressure of 4 inches Hg at an ambient temperature of 40°F without the use of the surface condenser.
3.  Design ACC to maintain turbine exhaust pressure no lower than 2 inches Hg under any ambient conditions between 40°F and the and the extreme ambient low temperature.
4.  The ACC must be capable of continuous operation without internal or external ice buildup (freezing) by incorporation of various design features such as fan speed variation, sectionalizing (steam isolation valves), isolation from the ambient environment (louvers), and air recirculation.
5.  The control logic should be designed to maintain the backpressure by optimizing the fan speed for the ambient conditions and the steam turbine exhaust energy. The control logic shall also
automatically protect the system from freezing by varying fan speed, isolating cells, or closing louvers.

1.04 BASIS OF PERFORMANCE GUARANTEES

A. TURBINBE EXHAUST ENERGY
   1. As defined in Section 00 43 33.

B. INSTRUMENT AIR
   1. The Buyer shall supply adequate instrument air at the following conditions:
      a. Supply Pressure: 80-125 psig
      b. Dew Point: -40.0 °F
      c. Compressor Type: As required by Seller

1.05 TUNING PERIOD

A. The Seller shall be afforded 30 calendar days to allow for condensing system performance adjustments (tuning) prior to the start of testing.

B. The tuning period may be extended upon request of the Seller and at the discretion of the Buyer.

C. The tuning period shall end no later than 21 calendar days prior to an emissions testing deadline mandated by the Air Permit or any applicable state or federal statutes.

D. The tuning period will be used to check equipment operation and functionality and make any modifications necessary prior to guarantee testing.

1.06 CONDENSING SYSTEM DEMONSTRATION

A. Demonstration will occur during the start-up and commissioning period of the project.

B. Seller shall demonstrate that the equipment provided can meet the Operational Requirements set forth in Paragraph 1.03 of this Section.

C. Seller shall demonstrate that the equipment provided can operate during automatic transitions between ACC freeze protection modes.

D. Seller shall demonstrate the opening and closing of the freeze protection devices.

1.07 PERFORMANCE TESTS

A. Performance testing will consist of:
   1. Steam generator performance test
   2. Condensing system pressure test
   3. Auxiliary power consumption test

B. General Requirements for all performance testing
   1. Plant instrumentation will be utilized to the greatest extent possible while still maintaining an acceptable test uncertainty or tolerance.
   2. The Buyer and Seller shall agree to a calibration procedure prior to testing.
   3. All performance tests shall be executed by Buyer or a buyer supplied independent third party (experienced in such work and mutually acceptable to Buyer and Seller).
   4. Buyer will notify Seller in writing at least two (2) weeks prior to the scheduled performance test date. It shall be Seller's responsibility to furnish a test observer on the scheduled date.
   5. If any individual performance test identified in 1.07.A requires a retest, it may be run separately.
   6. The Seller's representative shall act in an advisory capacity and shall have access to all pertinent test records at all times. Any performance test(s) shall be conducted in a manner to satisfy the Seller that the specified performance conditions are being maintained.
7. The equipment supplied by Seller shall be operated and maintained according to Seller's guidelines, good engineering and operating principles and Seller's Maintenance and Operating manual, both prior to and during the performance testing. The Seller shall not be responsible for the deterioration or failure of any equipment resulting from improper maintenance and operation or the failure to observe applicable O&M instructions and written recommendations of the Seller and its subvendors.

C. Initial condensing system performance tests will be run concurrently with performance testing of other major equipment. Availability test may not be run concurrently with performance tests.

D. The performance guarantees are subject to the following provisions:
   1. All replacement parts shall be of Seller's manufacture or supply, unless in Seller's judgment parts supplied by others are of equal or superior quality.

E. Buyer will provide Seller with copies of the final test report, including all raw data in electronic format, within two (2) months of the conclusion of the performance testing.

F. The equipment shall be started-up in presence of a Seller Service Representative. Immediately prior to testing, the equipment shall be operated at a constant rating for a period that is sufficient to demonstrate steady state operation, based upon steam turbine exhaust output. Steady state conditions shall be maintained during the test period.

G. The duration of the test period shall be the minimum required for obtaining representative data but shall not be less than 4 hours.

H. Buyer will utilize the plant historian to record pertinent data collected by the plant DCS. Buyer or third party testing firm will provide and maintain any temporary instrumentation and data logging equipment necessary to obtain additional test data. Buyer will also maintain equipment maintenance logs necessary to monitor operation, from the initial equipment start-up date through the final performance-testing period.

I. All process streams shall be sampled or measured simultaneously.

J. Test tolerance, unless agreed to by all parties due to deviation from ASME PTC test methods, will not be applied to corrected test results prior to comparison to guaranteed values.

K. The procedures described in ASME PTC 12.2, PTC 24 and PTC 30.1 may be modified by mutual agreement of all parties to minimize complexity and cost while maintaining an acceptable test certainty. Should the parties be unable to agree on modifications of the performance test codes, the test shall be conducted in accordance with the test codes with the exception that existing plant instrumentation will be utilized to every extent possible.

L. Auxiliary Power Consumption Test:
   1. The auxiliary power consumption will be measured during quantity of four one hour long performance test periods. Auxiliary power will be measured by summing the power consumption of the equipment listed below using either station and/or portable measurement equipment of reasonable accuracy that has been calibrated within the last year.
   2. The auxiliary power consumption shall be recorded for the following equipment:
      a. Air Cooled Condenser Fans
      b. Vacuum Pumps
      c. Any other equipment supplied by Seller that is rated at 5 HP or larger and is in continuous use during normal condensing system operation. Where power consumption instrumentation is not provided as a part of the plant design, the Buyer shall furnish temporary instrumentation to collect the necessary data.
   3. The power consumption is to be determined at the motor inlet, or other affected device leads.
   4. Applicable ASME PTCs shall be used as general guidelines to develop the detailed test procedures.

M. Steam Consumption Test:
1. The auxiliary steam consumption will be measured during quantity of four fifteen minute long performance test periods. Steam consumption will be measured in accordance with ASME PTC 24.

2. The steam consumption shall be recorded for the following equipment:
   a. Steam Jet Air Ejector (SJAE) (Holding)

3. ASME PTC 24 shall be used as a general guideline to develop the detailed test procedure.

N. Performance tests and performance calculations shall be made in accordance with the codes and procedures identified in this section or other mutually agreed upon methods in effect as of the original date of the proposal submittal, and the measure of performance shall be the results of such tests. The guaranteed values as stated in Section 00 43 33 are contingent upon measurement in accordance with the following test procedures:
   1. Condensing System
      a. ASME PTC 12.2 2010 (Steam Surface Condenser)
      b. ASME PTC 30.1 2007 (Air-Cooled Steam Condensers)
      c. ASME PTC 24 (Ejectors)
      d. 
   2. Steam Properties
      a. "Thermodynamic Properties of Steam" per the 1997 ASME Steam Tables

O. Test Corrections
   1. Test corrections will be conducted as specified by the applicable PTC

1.08 ADDITIONAL CONSIDERATIONS

A. Should the condensing system performance be limited by equipment outside of the Sellers scope of supply such that the condensing system is not able to reach the guaranteed conditions, the Buyer, at their option, may choose one of the following:
   1. Waive any further testing and accept the condensing system performance as is
   2. Postpone any further testing until the underperforming equipment can be repaired. Subsequent condensing system performance testing will be at the Buyers expense and shall be limited to a single retest. The guarantees shall be deemed to be met should the condensing system fail to achieve the guaranteed conditions due to limitations caused by the Buyers equipment upon retest.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

NOT USED

END OF SECTION

1) R. Hernandez
2) J. Solan
PART 1    GENERAL

1.01 SECTION INCLUDES

A. Structural materials.
B. Structural design requirements.
C. Structural fabrication and erection.
D. Shop primer.
E. Inspection and testing.

1.02 WORK BY OTHERS

A. Foundations and column anchor bolts.
B. Field touch-up coating.

1.03 DESIGN REQUIREMENTS

A. Design and furnish structural steel and structural steel connections.
B. Design in accordance with 2009 International Building Code, AISC "Specification for Structural Steel Buildings" March 9, 2005, and these specifications, whichever is more stringent.
C. Structural Performance Requirements: Section 01 83 00.
D. Design shall be performed by professional structural engineer(s) licensed in the State of Alaska, retained by Seller.
E. Column baseplate design shall be based on foundation concrete with 4,000 psi compressive strength. Baseplate design shall not be based on an increase in concrete bearing strength (per ACI 318) due to supporting surface having a larger area than bearing surface.
F. Base plate shear forces shall be transmitted to foundation by use of shear bars welded to bottom of baseplate. Design shall be based on concrete with 4,000 psi compressive strength. Grout shall not be included in the bearing area.
G. Column design shall assume columns are pin-connected (theoretical condition) to foundations.
H. Elevated platforms shall consist of welded steel grating.

1.04 SUBMITTALS

A. Product Data:
   1. List of manufactured materials proposed, identifying manufacturer and type.
   2. Manufacturer's installation and inspection instructions for direct tension indicator washers.

B. Steel engineering (design) Submittal Drawings:
   1. Drawings showing general arrangement framing plans, sections and details of steel designed by Seller.
   2. Shall be sealed by engineer licensed in the State of Alaska.
   3. Submit for review prior to development of Fabrication Drawings.
4. Revised engineering drawings shall be labeled with revision number and revision date with all changes clearly identified by triangles and tables and sealed by engineer retained by Seller certifying drawing revision.
5. List design shears, moments, and axial forces on Design Drawings.

C. Shop Drawings:
1. Shop Drawings will be reviewed by Buyer.
2. Shop Drawings for structural material shall include erection plans and connection details.
3. The Sellers Shop Drawings depicting connection design by Sellers structural design engineer shall be reviewed, signed, and dated by Sellers engineer.
4. Revised Shop Drawings shall be labeled with revision number and revision date with all changes clearly identified by triangles and tables and signed and dated by Seller's connection design engineer.
5. Drawings shall distinguish between shop and field welds.
6. All drawings requiring engineering design on the part of the fabricator shall be signed and sealed by a Professional Engineer registered in the State of Alaska.

D. Column base plate loads to foundations.
1. For each type of load (e.g., dead load, live load, north to south wind load, south to north wind load, north to south seismic load, etc.), for each base plate list:
   a. Magnitude of force.
   b. Direction of force.
2. Loads shall not be combined or factored.
3. Load data shall also be submitted electronically in Excel spreadsheet format.

E. Quality assurance data:
1. Certificates of compliance with standards specified for items specified in this Division.
2. Certified copies of mill tests.
3. Maintain copies of Welder's qualifications at Sellers facilities.
4. Weld inspection and testing reports: Maintain copies of reports at Sellers facilities. At a minimum, reports shall contain following information:
   a. Inspecting agency, inspector, inspector's AWS certification, materials inspected, date of inspection, whether or not materials conformed to Contract requirements, repair work and follow-up inspection results.
   b. Fabricator's AISC shop certification.
   c. Weld test reports.
5. Bolted connection inspection and testing reports: Maintain copies of report at Sellers facilities. Report shall contain following information:
   a. Inspecting agency, inspector, and inspector's qualifications.
   b. Connections tested and inspected, and date of test and inspection.
   c. Whether or not connection conformed to contract requirements, rework of connections, and follow-up testing and inspection results.
6. Within 30 days prior to start of steel erection, submit a letter to Buyer certifying that design of structures was performed in accordance with 2009 International Building Code and Contract Documents. Letter shall be signed and sealed by same professional engineer that seals structural design Drawings.

1.05 QUALITY ASSURANCE

A. Fabricator qualifications:
1. Not less than 5 years experience in fabrication of building structural steel.
2. Certified by AISC Quality Certification Program.

B. Buyer will retain services of qualified, independent testing company to inspect and test fastener assemblies, installation and tightening of bolts; and to perform inspection and testing of welds.
C. Where tests or inspections indicate noncompliance with Contract Documents, repair or replace defective materials. Costs for retesting shall be borne by Seller.

PART 2 PRODUCTS

2.01 MATERIALS

A. Structural steel, W and WT shapes: ASTM A992/A992M, Grade 50

B. Structural steel, C, MC, S and L shapes, and plates: ASTM A572, Grade 50, ASTM A529, Grade 50, ASTM A992/A992M, Grade 50 or ASTM A36/A36M.

C. Structural square and rectangular tubing: ASTM A500, Grade B.

D. Structural pipes: ASTM A53/A53M, Grade B.

E. Round HSS: ASTM A500, Grade B.

F. Steel fasteners, plain finish:
   1. High-strength bolts: ASTM A325/A325M, Types 1 or 3, or ASTM A490/A490M, Types 1 or 2, cold-forged, domestically manufactured.
   3. Washers: ASTM F436/F436M; hardness of 38 to 45 H.C.
   4. Direct tension indicators: ASTM F959/F959M.
   5. Twist off tension control bolts conforming to ASTM F1852 may be substituted for A325 bolts. Heads shall be heavy hex type.

G. Steel fasteners, galvanized:
   1. High-strength bolts: ASTM A325/A325M, Type 1 only.
   2. Nuts: ASTM A194/A194M 2H or ASTM A563/A563M DH.
   3. Washers: ASTM F436/F436M; hardness of 38 to 45 HRC.
   4. Direct tension indicators: ASTM F959/F959M.
   5. Bolt, nut, and washer galvanizing: ASTM B695, Class 50 or ASTM A153/A153M. Tapping and lubricating of nuts in accordance with ASTM A563/A563M.
   6. Direct tension indicator galvanizing: ASTM B695, Class 50 only.


I. Stainless steel: ASTM A240/A240M, Type 304 or 316.

J. Galvanizing: ASTM A123/A123M.

2.02 STEEL FABRICATION


C. Connection details and design:
   1. Connections shall be designed by professional structural engineer retained by Seller.
   2. Design each beam end connection for larger of following:
      a. Shear load determined from design loads.
b. 50% of total uniform load capacity computed from "Allowable Loads on Beams," tabulated in AISC Manual of Steel Construction, 13th Edition, for given shape, span, and steel specified assuming beam is fully-laterally supported.
c. 50% of uncoped beam web shear capacity.

3. Design hanger and diagonal bracing member connections for shear, axial tension and compression forces. Design end connections of horizontal members in braced vertical frames and horizontal trusses for combination of axial force and beam shear reaction.

4. Design moment connections:
   a. Assume that moment connection angles, structural tees, or plates above top flange and below bottom flange do not carry any portion of shear load.
   b. Where moment connection occurs at grating platform, arrange top plate of moment connection flush with grating surface. Provide edge support for grating at moment connections.
   c. Provide stiffener plates between column flanges opposite points of beam flange moment connections, wherever required to prevent column web crippling or buckling of column flanges.
   d. Provide column web doubler plates as required.
   e. Design moment connections for field bolting as much as possible.

5. Use slip-critical connections shall be per the requirements of AISC 360 and 341.

6. Other connections not specified as slip-critical may be bearing-type connections, designed assuming threads in shear plane. Clearly identify connections as being slip-critical or bearing-type connections on Shop Drawings.

D. All high strength bolts shall be pre-tensioned in accordance with the AISC "Specification for Structural Joints Using ASTM A325 or A490 Bolts", using direct-tension indicator tightening method, regardless of whether pre-tensioning is required or not by design. Use direct-tension indicator washers under non-turning part of bolt assembly.

E. Shop connections: Either weld or use high-strength bolts.

F. Field connections: Provide bolts for field connections.
   1. Use high-strength bolts. Use galvanized high-strength bolts when bolting galvanized steel.
   2. Use of high-strength bolts: Conform to "Specification for Structural Joints Using ASTM A325 or A490 Bolts," as approved by Research Council on Structural Connections of the Engineering Foundation, and published by AISC.
   3. Minimize field welding. Provide as much welding as practicable in shop.

G. Detail single angle cross bracing to require light drifting to draw holes together resulting in small amount of initial tension in diagonals.

H. Column finishes at baseplates and at splices shall meet a surface roughness tolerance of 500 in accordance with ANSI B46.1 by milling, saw cutting, or other suitable means.

I. Close ends of pipe and tubular members with minimum 10-gage plate, seal welded to member.

J. Arrange structural members to minimize pocketing of dust and moisture.

K. Provide 2" diameter drainage holes at 4'-0" maximum spacing where framing member orientation may trap water.

L. Seal weld exterior welded connections to prevent entrance of water.

M. Interior simply supported beam-to-column and beam-to-beam connections shall be double clip angle type connections.
N. Minimum thickness of exterior structural shapes and plates: 5/16", except webs of W-beams, tees, and channels which may be 1/4" minimum thickness.

O. Interior double angles or double-tee or double-channel compression members:
   1. Provide spacer plates at intervals such that compressive strengths of individual members between spaces is at least equal to that of double member for its total length.
   2. Connect members with spacer plates of same metal quality by bolting or shop welding.

P. Use of double angle, double tee, and double channel framing members is not permitted for exterior framing. Built-up sections are permitted for exterior use if sections are seal welded together to prevent entrance of moisture.

2.03 SHOP FINISHES

A. Surface preparation:
   1. Structural steel shapes: Remove oil, grease, dirt, rust, loose mill scale, and other foreign elements by "Commercial Blast Cleaning" in accordance with SSPC-SP6.
   2. Guardrail, ladders and grating: Remove oil, grease, dirt, rust, loose mill scale, and other foreign elements by "Power Tool Cleaning" in accordance with SSPC-SP3 or "Commercial Blast Cleaning" in accordance with SSPC-SP6.

B. Omit primer from contact surfaces of slip-critical connections unless primer has been qualified by test in accordance with "Test Method to Determine the Slip Coefficient for Coatings Used in Bolted Joints" as adopted by the AISC Research Council on Structural Connections. Manufacturer's certification shall include certified copy of test report.

C. Omit shop prime coats:
   1. Sufficient distance from surfaces subject to field welding to prevent coating damage from welding process.
   2. From surfaces to be embedded in concrete.
   3. From galvanized surfaces and stainless steel.

D. Leave unpainted steel clean and free from rust.

E. Shop primer: As specified in Section 09 92 00.

PART 3 EXECUTION

3.01 INSPECTION AND TESTING OF BOLTED CONNECTIONS

A. Inspection and testing: In accordance with Section 9 of "Specification for Structural Joints Using ASTM A325 or A490 Bolts," Direct Tension Indicator (DTI) manufacturer's installation and inspection instructions, and these specifications.

B. Inspection and testing will also include following:
   1. Verify that bolt, nut, washer, and DTI types conform to materials specified.
   2. Verify bolts, nuts, washers and DTI are properly marked in accordance with appropriate ASTM specifications including manufacturer symbol.
   3. Verify appropriate test certificates have been furnished by manufacturer for bolts, nuts, washers and DTI washers according to ASTM specification requirements.
   4. Verify certificate lot numbers coincide with lot numbers on containers at job site.
   5. Perform DTI calibration test and bolt assembly load test using Skidmore Wilhelm bolt tension calibrator. Minimum of 3 assemblies for each diameter and grade of bolt, nut, hardened washer and DTI will be tested for each shipment.
   6. Verify bolting crews are installing bolts in accordance with references specified.
7. Verify slip-critical connection bolts and bolts subject to tension have been properly pretensioned using feeler gage and visual inspection in accordance with DTI manufacturer’s written instructions.
8. Verify bearing-type connection bolts are snug tight bringing all plies into contact.

3.02 INSPECTION AND TESTING OF SHOP WELDS

   1. Welds shall be visually inspected in accordance with AWS D1.1.

B. Nondestructive testing: AWS D1.1.
   1. Shop full penetration welds of structural shapes: Test full length of welds.
   2. Test base metal having thickness more than 1-1/2” (38 mm) and subject to through-thickness weld shrinkage strains. Nondestructive testing: Ultrasonic method conforming to AWS D1.1.

C. Repair welds shown by inspections or testing to have discontinuities that would reduce weld strength in accordance with AWS D1.1. Cost of reworking welds and follow-up inspections and tests shall be borne by Seller.

D. Buyer may review welding procedures and completed welds at fabricator’s shop during fabrication.

END OF SECTION

1) K. Koch
2)
PART 1   GENERAL

1.01 SECTION INCLUDES
   A. Handrails and guardrails.
   B. Self-closing gates.
   C. Ladders.
   D. Grating.
   E. Stair treads.
   F. Checkered plate.
   G. Shop primer.
   H. Provisions of this section apply to boiler island metal fabrications unless noted otherwise.

1.02 WORK BY OTHERS
   A. Anchor bolts, steel embedments, and blockouts in concrete for equipment and structures furnished
      under this Contract.

1.03 DESIGN REQUIREMENTS
   A. Design and furnish miscellaneous metals, connections and associated components.
      International Building Code and these specifications.
   C. Design shall be performed by a professional structural engineer registered in the State of Alaska,
      retained by Seller.
   D. Structural Performance Requirements: Section 01 83 00.

1.04 QUALITY ASSURANCE
   A. Perform welding in accordance with AWS D1.1 "Structural Welding Code".

1.05 SUBMITTALS
   A. Product Data: List of manufactured materials proposed, identifying manufacturer and type.
   B. Steel engineering (design) Drawings:
      1. Drawings showing general arrangement of steel designed by Seller.
      2. Shall be sealed by engineer licensed in the State of Alaska.
      3. Submit for review prior to development of Shop Drawings.
      4. Revised engineering drawings shall be labeled with revision number and revision date with all
         changes clearly identified by "clouding," and sealed by engineer retained by Seller certifying
         drawing revision.
   C. Steel Shop Drawings:
      1. Steel shop drawings submitted for review.
2. Shop Drawings for structural material including erection plans and connection details.
3. Each Shop Drawing depicting connection design by Seller connection design engineer shall be reviewed, approved, signed, and dated by such engineer.
4. Revised Shop Drawings shall be labeled with revision number and revision date with all changes clearly identified by "clouding" and signed and dated by Seller connection design engineer.
5. Drawings shall distinguish between shop and field welds.

PART 2 PRODUCTS

2.01 MATERIALS

A. Stainless steel: ASTM A240/A240M Type 304, Type 304L or Type 316.
B. Galvanizing: ASTM A123/A123M.
D. High-strength bolts: ASTM A325/A325M, Types 1 or 3.

2.02 STEEL HANDRAILS AND GUARDRAILS

A. Material: ASTM A53/A53M, Grade B or ASTM A501.
B. Use 1-1/4" diameter standard weight steel pipe for rails and uprights. Maximum spacing of uprights: 6'-0". Provide two rails.
C. Connections: Weld and grind smooth.
D. Bend pipe at corners; do not miter pipe.
E. Provide removable rails where required.
F. Provide 1/4" x 4" high kickplate.

2.03 SELF-CLOSING GATES

A. Type: Prefabricated, galvanized steel gate with stainless steel spring to automatically close gate; 12" (300 mm) high by required length.
B. Manufacturer: Model A-71 "Safety Gate" by Fabenco Inc., or equal.
C. Provide self-closing gates at platform entrances to ladders.

2.04 STAIR TREADS

A. Stairs shall be used in the design where practical.
B. Stairs shall be a minimum 36" wide, with concrete filled steel pan treads.
C. Stairs to work platforms can be steel treads with abrasion or checkered plate nosings.
D. Steel treads: prefabricated standard galvanized steel grating with galvanized checkered plate abrasive nosing; minimum grating bar size:
   1. For 3'-0" wide stairs: 1\" x 3/16\".
   2. For 3'-1" to 4'-0" wide stairs: 1-1/4\" x 3/16.
E. Provide abrasive or checkered plate nosing at head of each steel stairway at grating floor surface.

2.05 ALTERNATING TREAD STAIRS

A. Alternating tread stairs shall be used for applications where stairways are not practical.


C. Stair maximum slope is 70 degrees measured from horizontal on the side opposite the climbing side.

D. Alternating stair device shall be support a minimum uniform load of 100 psf and a minimum concentrated load of 300 lbs at the center of any tread span.

E. Stair shall be equipped with handrails on both sides.

F. Stair width, between handrails, shall be 17 to 24 inches.

G. Stair tread surfaces shall be slip resistant.

H. Stair tread depth shall be a minimum of 8.5”.

I. Stair tread opening shall be a minimum of 7”.

2.06 STEEL LADDERS

A. Steel ladders shall be used for applications where alternating tread stairs are not practical.

B. Conform to requirements of OSHA.

C. Provide self-closing gates with ladders.

D. Rung type: Steel, 4-row, 13-gage tread-grip (with end notching for fit-up with ladders utilizing pipe rail) by Morton Manufacturing Co., or equal.

E. Provide safety cages and intermediate platforms as required by OSHA.

F. User vertical slip connection at ladder locations where connecting to concrete slab-on-grade to accommodate slab settlement.

2.07 STEEL GRATING

A. Use welded rectangular grating conforming to standards of NAAMM at stair landings and access platforms.

B. Use plain grating, except use serrated grating for exterior and sloping walkways. Provide sloping sections with grating bars orientated normal to walking direction.

C. Minimum size of bearing bars: 1-1/4” x 3/16” at 1-3/16” oc.

D. Make sections removable; limit weight of each section to not more than 150 lb.

E. Provide saddle clip fasteners for each removable section of floor bar grating supported on structural steel members.
F. Provide edge banding at exposed edges to stiffen irregular sections. Provide 1/4” x 4” high kick plate at openings required for passage of piping, ducts, chutes, or other items. Provide joints at center of openings where possible to permit removal of grating around items passing through.

G. Grating, plates welded to grating, and grating saddle clips shall be galvanized.

2.08 STEEL CHECKERED PLATE

A. Material: ASTM A786/A786M, Fig. 3, Patterns 3, 4, or 5, 1/4” thick.

B. Use of checkered plate is not permitted where floor design load exceeds 100 psf and at equipment laydown areas.

C. Provide stiffener angles at checkered plate joints welded to one plate and fastened to the other. Provide stiffener angles, bars or other supports to limit deflection to 1/300 of span using a live load of 60 psf (2.4 kPa) as basis for calculating deflection.

D. Provide 1/4” x 4” high kick plate at openings required for passage of piping, ducts, chutes, or other items. Provide joints at center of openings where possible to permit removal of checkered plate around items passing through.

E. Make floor plate sections removable; weight of each section not more than 150 lb.

F. Provide 2 holes, slotted, round ends, 3/4” x 1-1/2”, for lifting each section of floor plate; ream holes to remove burrs. Use lift handles at maintenance access areas.

2.09 SHOP PRIMER

A. Conform to requirements of Section 05 10 00, except use of "Power Tool Cleaning" for handrails, guardrails, ladders, checkered plate, and grating is permitted.

PART 3 EXECUTION

Not Used

END OF SECTION

1) K. Koch
2)
PART 1 GENERAL

1.01 SECTION INCLUDES

A. Shop surface preparation, unless otherwise specified.
B. Shop prime painting.
C. Finish painting of major equipment provided by sub-vendors.

1.02 WORK BY OTHERS

A. Field finish painting.

1.03 SCOPE

A. Paint all ferrous steel surfaces prior to shipment unless directed otherwise herein. Surfaces include, but are not limited to:
   1. Structural and supplementary steel.
   2. Exterior surfaces, including those that are to be covered by insulation in the field.
   3. Piping, including pipes that will be insulated in the field.
   4. Ductwork, including ducts that will be insulated in the field.
B. Slip critical steel connection faying surfaces shall not be coated.
C. Finish paint all equipment supplied by sub vendors. Color to be manufacturer standard unless indicated otherwise in the specification section relating to the specific piece of equipment.

1.04 SUBMITTALS

A. Submittals shall clearly indicate that products satisfy the requirements provided herein.
B. Product data sheets, if other than products specified.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Where supply of paint to the project site is specifically called for by this contract, deliver paint materials in sealed original labeled containers, bearing manufacturer's name, type of paint, brand name, color designation and instructions for mixing and/or reducing.

1.06 ENVIRONMENTAL REQUIREMENTS

A. Environmental conditions in facilities utilized to apply coatings to equipment supplied under this contract shall be in strict accordance with the coating system manufacturer’s recommendations and requirements.
B. Do no exterior painting while surfaces are damp or during rainy or frosty weather.
C. Do no exterior spray painting while the wind velocity is above 13 mph.
D. Provide adequate continuous ventilation and sufficient heating facilities to maintain temperatures as required by manufacturer for 24 hours before, during and 48 hours after application of finishes.
E. Provide adequate lighting on surfaces to be finished.
1.07 HEALTH AND SAFETY REQUIREMENTS

A. Where supply of paint to the project site is specifically called for by this contract, the following requirements apply:
   1. Toxic compounds: Toxic compounds having ineffective physiological properties, such as odor or irritation levels, shall not be used unless approved by Owner.
   2. Provide paints for interior use that contain no mercurial mildewcide or insecticide. Provide paint containing not more than 0.06% lead.
   3. Provide documentation stating that paints proposed for use meet Volatile Organic Compound (VOC) regulations of local air pollution control districts having jurisdiction over geographical area in which Project is located.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Acceptable Manufacturers
   1. Carboline
   2. Ameron
   3. Sherwin Williams
   4. Tenemec

B. Materials and colors referenced are as manufactured by Carboline, unless noted otherwise. Equivalent products from other manufacturers are acceptable.

2.02 MATERIALS

A. Paints: Ready-mixed except field catalyzed coatings. Pigments fully ground maintaining soft paste consistency, capable of readily and uniformly dispersing to complete homogeneous mixture.

B. Paints to have good flowing and brushing properties and be capable of drying or curing free of streaks or sags.

C. Dry mil thickness of paint shall comply with manufacturer’s recommendations for materials specified for prevailing substrates and Project conditions.

D. Paints containing lead in excess of 0.06% by weight of total nonvolatile content (calculated as lead metal) shall not be used.

E. Paints containing zinc chromate or strontium chromate pigments shall not be used.

F. VOC content: Paints shall comply with applicable state and local laws enacted to ensure compliance with Federal Clean Air Standards and shall conform to restrictions of local air pollution control authority.

2.03 SHOP PREPARATION

A. Structural and miscellaneous steel.
   1. Surface preparation:
      a. Surface preparation: Remove oil, grease, dirt, rust, loose mill scale, and other foreign elements by "Commercial Blast Cleaning" in accordance with SSPC-SP6. Surface profile shall comply with paint manufacturer’s requirements.
      b. "Power Tool Cleaning" in accordance with SSPC-SP3 is permitted for handrails, guardrails, ladders, checkered plate, and grating.
   2. Shop painting:
      a. Omit paint from contact surfaces of slip-critical connections.
b. Omit shop prime coat:
   1) Sufficient distance from surfaces subject to field welding to prevent prime coat damage from welding process
   2) From surfaces to be embedded in concrete.
   3) From galvanized surfaces,
3. Leave steel surfaces not painted in shop clean and free from rust.

B. Grating, treads, and kick plates:
1. Galvanized: Thoroughly clean steel and galvanize in accordance with ASTM A123/A123M.

PART 3 EXECUTION

3.01 INSPECTION

A. Thoroughly examine surfaces scheduled to be painted prior to commencement of Work. Report in writing to Engineer, any condition that may potentially affect proper application. Do not commence until such defects have been corrected.

B. Correct defects and deficiencies in surfaces which may adversely affect work of this Section.

3.02 PROTECTION

A. Adequately protect other surfaces from paint and damage. Repair damage as a result of inadequate or unsuitable protection.

3.03 PREPARATION

A. Iron and steel surfaces:
   1. Cleaning methods: Conform to applicable requirements of SSPC and NACE:
      a. Solvent cleaning: SSPC-SP1.
      b. Power tool cleaning: SSPC-SP3.
      c. Commercial blast cleaning: SSPC-SP6 or NACE 3.
      d. Power tool cleaning to bare metal: SSPC-SP11.
      e. Blast cleaning requirements: SSPC-SP6 or SSPC-11 for areas where abrasive blast is prohibited.
   2. Removal of materials such as grease and oil: SSPC-SP1. Apply treatment of phosphoric acid solution, ensuring weld joints, bolts and nuts are similarly cleaned. Prime surfaces to indicate defects, if any. Paint after defects have been remedied.
   3. Surface irregularities from blasting shall be approximately 25% of total paint system dry mil thickness.

B. Prepare surfaces to be finished in conformance to recommendations of finish manufacturer.

3.04 APPLICATION

A. Apply coating at proper consistency. Materials shall be evenly spread and applied smoothly without runs or sags, by skilled workers. Do painting under conditions suitable to production of high quality work. Follow manufacturer's directions on container label.

3.05 PAINT SYSTEM

A. System A: Interior and exterior structural steel framing, miscellaneous structural steel, and miscellaneous metals (except as noted for System B).
   1. First coat: Carboline “Carboguard 888”, 4 to 6 mils dft
   2. Finish color will be selected by Owner.
B. System B: Guardrails, Handrails, and Ladders
   1. First coat: Carboline "Carboguard 888", 4 to 6 mils dft
   2. Finish coat: Carboline "Carbothane 133HB", 3 to 5 mils dft
   3. Finish color will be selected by Owner. Use "Safety Yellow" color for guardrails, handrails, self-closing gates and ladders.

END OF SECTION

1) K. Koch
2) R. Hernandez
PART 1 GENERAL

1.01 SECTION INCLUDES

A. General electrical requirements for equipment and services including, but not limited to:
   1. Factory wiring.
   2. Low voltage field wiring.
   3. Low voltage splices and terminations.
   4. Low voltage cabinets and electrical enclosures.
   5. Equipment safety grounding.
   6. Low voltage fuses and fuse blocks.
   7. Electrical meters.
   8. Control relays and switches.
  10. Indicating lights.
  11. Alarm and trip contacts.
  12. Low voltage starters.
  13. Low voltage circuit breakers and disconnect switches.
  15. Power factor correction capacitors.
  16. Outlet, pull, and junction boxes.
  17. Plates and covers.
  18. Wiring devices,
  20. Panelboards.
  21. Welding.
  22. Shop finish.
  23. Rust-inhibiting compounds.
  25. Packaging, identification, and tagging.
  27. Trip setting coordination.
  28. Grounding and bonding.
  29. Fireproofing and fire ratings.
  30. Testing and demonstration.

B. Section is generic in nature and may contain technical requirements for equipment that is not included in the scope of this contract. Seller shall rely on Sections 01 10 00 – Summary, 01 11 00 – Division of Responsibility, and 01 18 00 – Terminal Points for direction as to the scope of supply.

C. Content of this section is not intended to define Seller’s scope of supply.

1.02 INFORMATIONAL SUBMITTALS

A. Product Data:
   1. List of proposed material identifying manufacturer, type and model number for equipment to be provided for complete job.
   2. Manufacturer’s catalog sheets marked to indicate specific type, model or catalog number of equipment to be provided.
   3. Equipment drawings, elementary diagrams, schematics, wiring, performance curves, instruction manuals, and all other documentation necessary for complete description of material being supplied and as required to support installation, commissioning and maintenance of equipment. Manufacturer’s standard connection diagram or schematic showing more than one scheme of connection will not be accepted.
   4. Manufacturer’s technical descriptions, product data sheets, and applicable manuals for use in protective device system coordination including:
      a. Fuse manufacturer, type, ratings, and protection curves.
      b. Circuit breaker manufacturer, type, trip setting ranges, and protection curves.
c. Relay trip device ranges, curves, and setting manuals.

d. Transformer damage curves.

e. CT ratios and saturation curves.

f. VT ratings.

5. List of recommended spare parts required for equipment start-up, commissioning and operation.

6. List of special maintenance tools required for installation and operation of equipment.

7. If necessary, provide additional data to clearly demonstrate that proposed alternate equipment meets or exceeds equipment as specified.

8. When requested by Engineer, submit system information, including but not limited to, utility feeders, existing relays, circuit breakers, fuses, and transformers.

1.03 CLOSEOUT SUBMITTALS

A. Operation and maintenance manuals. Provide at minimum:
   1. Itemized equipment list.
   2. General description and technical data.
   3. Receiving, storage, installation, and testing instructions.
   4. Operating and maintenance procedures.
   5. Complete set of final drawings requiring no further action.
   6. Complete documentation of inspections and tests performed, including logs, curves, and certificates. Documentation shall note any replacement of equipment or components that failed during testing.
   7. Spare parts list.
   8. Lubrication recommendations.

B. Reference Section 01 78 23 – Operating and Maintenance Data for additional requirements.

1.04 MAINTENANCE MATERIALS

A. Extra materials: Provide touchup paint in same type and color to repair at least 25% of finish-painted equipment surface. Paint shall be sufficient to perform touch-up painting in accordance with shop-applied material instructions for repair painting.

B. Each piece of equipment shall be furnished with special tools as required for installation, maintenance, and dismantling of equipment.
   1. Furnish in quantities as necessary to complete work on schedule.
   2. Tools shall be new and shall become property of Buyer.
   3. Tools and intended use shall be identified in assembly instructions. Tools shall only be used for their intended purpose.

1.05 QUALITY ASSURANCE

A. Manufacturer qualifications:
   1. Manufacturer of equipment specified shall be recognized in industry for normally supplying this type of equipment.
   2. Manufacturer shall be ISO certified.
   3. When requested by Engineer, provide list of similar equipment installations that have employed identical equipment from manufacturer.

B. Materials and equipment furnished for permanent installation shall be new, unused, and undamaged.

C. Asbestos not allowed.

D. Parts shall be manufactured to American industry standard sizes and gages to facilitate maintenance and interchangeability. Metric sized components not allowed unless specifically requested by the Seller and approved by the Buyer.

1.06 DELIVERY, STORAGE, AND HANDLING
A. Pack, ship, handle, and store in accordance with manufacturer's requirements.

B. Ship equipment completely factory assembled unless physical size, arrangement, configuration, or shipping and handling limitations make this impracticable. Shipping splits and required field assembly shall be identified with equipment submittals.

C. Costs associated with sections, accessories, or appurtenances requiring field assembly shall be Seller’s responsibility.

D. Separately packaged parts and accessories shall be consolidated and shipped together with equipment. Mark each container clearly to identify contents and as belonging with main equipment.
   1. Provide individual weatherproof itemized packing slips attached to outside of each container for contents included. Provide duplicate inside each container.
   2. Attach master packing list, covering accessory items for equipment, to main piece of equipment.
   3. Mark each container with project identification number for equipment and container number followed by total number of containers.

E. Equipment shall be suitably protected during shipment, handling, and storage. Damage incurred during shipment shall be repaired at no cost to Buyer.

F. Equipment packaging shall be suitable for transport via oceangoing vessel.

G. Protect coated surfaces against impact, abrasion, and discoloration.

H. Electrical equipment and insulation systems shall be protected against ingress of moisture, including saltwater. Use space heaters if necessary to protect against moisture.

I. Exposed threads shall be greased and protected.

J. Pipe, tube, and conduit connections shall be closed with rough usage plugs. Seal and tape open ends of piping, tubing, and conduit.

K. Equipment openings shall have covers, to seal equipment.

1.07 SCHEDULING

A. Coordinate with Buyer early and late shipping and delivery schedules for items requiring storage and handling at Site.

1.08 WARRANTY

A. Electrical equipment shall be provided with manufacturer’s standard warranty, but not less than 1 year.

PART 2 PRODUCTS

2.01 DESIGN CRITERIA

A. Service conditions: Provide equipment and material suitable for intended service and installation at location indicated.

B. Low-voltage auxiliary and control power,
   1. Electrical power for ac control and instrumentation equipment:
      a. Provide devices necessary for proper operation and protection of equipment during electrical power supply and ambient temperature fluctuations specified.
      b. Design for continuous operation at any voltage from 85% to 110% of nominal voltage. Dropout voltage shall be 60% of nominal for relays and 75% for contactors and starters.
   2. Electrical power for dc devices:
a. Design for continuous operation on ungrounded station battery system, capable of maintaining operation at any voltage from 80% to 112% of nominal voltage.
b. Electrical devices served shall not impose ground connection on supply.

C. Auxiliary power: Design auxiliary equipment for low voltage service, with electrical power designed to operate from one of nominal electrical power sources as follows and as indicated on Drawings:

<table>
<thead>
<tr>
<th>Volts</th>
<th>Phase</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>480Y/277</td>
<td>3 or 1</td>
<td>60</td>
</tr>
<tr>
<td>208Y/120</td>
<td>3 or 1</td>
<td>60</td>
</tr>
<tr>
<td>120/240</td>
<td>1</td>
<td>60</td>
</tr>
<tr>
<td>125</td>
<td>1</td>
<td>Dc</td>
</tr>
<tr>
<td>24</td>
<td>1</td>
<td>Dc (loop)</td>
</tr>
</tbody>
</table>

D. Design equipment in accordance with seismic requirements listed in most recent local building codes, Section 01 83 00 – Structural Performance Requirements and Data Sheets.

2.02 MECHANICAL CONSTRUCTION

A. Provide recommendation for attachment of equipment to foundation or structural supports with design drawings, as applicable. Method of attachment will take into account seismic requirements of job site as indicated on Data Sheets and in Section 01 83 00 – Structural Performance requirements.

2.03 FACTORY WIRING

A. Select cable for electrical and environmental conditions of installation, and suitable for unusual service conditions where encountered.
   1. Proper temperature application cable shall be used throughout, but shall be not less than 90°C rated.
   2. Conductors routed over hinges shall use extra-flexible stranding.
   3. Cable insulation shall be rated for maximum service voltage used, but not less than 600 volts.
   4. Splices not allowed.

B. Panel, control cabinet, switchboard, motor control center, and switchgear wiring shall use flame retardant cross-linked polyethylene (XLP) or flame retardant ethylene-propylene rubber (EPR) insulation that meet or exceed requirements of UL 44 for Types SIS, and XHHW.
   1. Minimum size: No. 14 AWG (1.5 mm²).
   2. Conductors: Annealed bare copper with fine stranding passing IEEE 1202 and UL VW-1 flame test.

C. Instrumentation, thermocouple, and thermocouple extension wire shall use twisted shielded pairs/triads having flame retardant cross-linked polyethylene (XLPE) insulation, and chlorinated polyethylene (CPE) jacket.
   1. Minimum size: No. 16 AWG (1.0 mm²).
   2. Conductor type:
   3. Provide each pair/triad with shield.
   4. Shielding shall consist of aluminum-polyester tape and flexible strand tin-coated No.18 AWG (0.75 mm²) copper drain wire.
   5. Drain wire for each instrument cable shall be insulated with spaghetti sleeve. One end of shield wire shall be terminated on grounded terminal.
   6. Cables shall pass IEEE 1202 and ICEA 70,000 Btu/hr vertical tray flame test, and each conductor shall pass UL VW-1 flame test.

D. Terminations:
   1. Conductor terminal connectors shall be insulated, ring tongue, compression type connectors properly sized for conductor and terminal.
a. Connectors shall be constructed of copper and shall be tin-plated.  
b. Interior surface of connector wire barrel shall be serrated; exterior surface of connector wire barrel shall be furnished with crimp guides.

2. Uninsulated terminal connectors shall be used for conductors terminated on devices equipped with individual fitted covers, such as, but not limited to, control switches and lockout relays.

3. Connections requiring disconnect plug and receptacle type devices shall be provided with factory-terminated conductors on each plug and receptacle.
   a. Plugs and receptacles shall be factory wired into junction boxes containing terminal blocks for external connections.
   b. Conductors on disconnect portion of plug-receptacle assemblies shall be in common jacket.

4. Prior to shipment of equipment, remove temporary wiring installed in factory for equipment testing.

5. Current transformers shall terminate on shorting type terminal blocks. Ship with shorting jumpers installed.

E. Identification and labeling: 
   1. Provide conductor identification sleeve on each end of each internal conductor. Mark each sleeve with opposite end destination identification with non-smudging, permanent black ink. Sleeves shall be UV-resistant self-adhesive type or PVC, not less than 1/2” long.
   2. Permanently label each terminal block, terminal, conductor, relay, breaker, fuse block, and other auxiliary devices to coincide with identification indicated on manufacturer’s drawings.

2.04 SPLICES AND TERMINATIONS

A. Splices, except as in lighting and general purpose power circuits specified below, not allowed unless specifically indicated on Drawings or required for connection to equipment.

B. Temperature rating of splices and terminations: No less than 75°C.

C. Splices allowed in lighting and general-purpose power circuits.
   1. Provide wire and cable connectors of high-conductivity, corrosion-resistant material with contact area equal to at least current carrying capacity of wire or cable.
   2. General lighting and general-purpose building power circuits:
      a. Twist-type, insulated spring connectors for splices on solid or stranded conductors smaller than No. 6 AWG.
      b. Use indent, hex screw, or bolt clamp-type connectors, with or without tongue for splices on solid or stranded conductors No. 6 AWG and larger.
      c. Apply insulating 600-volt tape.

D. Insulating tapes and compounds for terminations and splices: UL-listed for intended use, location, and voltage by manufacturer.

E. Termination of conductors to equipment with bolted connections:
   1. Use compression type lugs:
   2. Compression lugs for cables 250 kcmil and larger shall have at least 2 clamping elements of compression indents, and provision for at least 2 bolts for joining to apparatus terminals.
   3. Crimping hand tools used for securing conductors in compression type connectors or terminal lugs shall be made for purpose and conductor sizes involved.
   4. Crimping tools shall be ratchet-type preventing tool from opening until crimp action is completed.
   5. Tools shall be product approved by connector manufacturer.

F. Terminals: 
   1. Conductors No. 10 AWG and smaller: Marathon 1500 Series.
   2. Conductors larger than No. 4/0 AWG: Terminate to tinned copper bus bar drilled and tapped with standard NEMA sized and spaced holes.

G. Coordinate sizes and types of conductor terminals for 600-volt power cable terminations in equipment with furnished conductor and terminal connector data.
H. Provide 600-volt rated terminal blocks for instrumentation and control conductors for connection to circuits external to specified equipment, and for internal circuits crossing shipping splits.
   1. Use crimp-on terminals matching termination point terminations in manufacturer-furnished panels. Splices not allowed.
   2. Terminal blocks for thermocouple extension wire: Buchanan “Medium Duty” with thermocouple contacts or Marathon 200 Series with Omega Engineering, Inc. Type TL terminal lugs.
   3. Furnish with white marking strips.
   5. Fuses may be mounted on terminal blocks.
   6. Maximum 2 conductors in accordance with termination point.

I. Terminal blocks for external connections shall leave from centrally mounted location, not from individual devices in enclosure.
   1. Group-in instrument and control compartment for easy accessibility.
   2. Provide sufficient space on each side of each terminal block to allow orderly arrangement of leads to be terminated on block.
   3. Locate auxiliary equipment in compartments, enclosures, or junction boxes so service personnel will have direct access without interference from structural members and instruments without removal of barriers, cover plates, or wiring.
   4. Do not mount terminal blocks in compartments containing cables or buses operating at voltages above 600 volts.
   5. Size for wire sizes of incoming conductors as necessary.

J. Circuit identification number listed on either circuit schedule or panel schedule shall be used to identify circuit, positioned as near as possible to end of each conductor on multiple single wire circuits and on cable jacket for multiconductor cables.

K. Cable designations shall be visible after installation without requiring physical movement of cable.

2.05 ELECTRICAL ENCLOSURES

A. Size junction boxes, pull boxes, and enclosures in accordance with requirements of NEC.

B. Junction boxes and pull boxes 4” (100 mm) trade size or smaller in any dimension shall be galvanized malleable iron, or cast ferrous metal NEMA rated for installed location. Do not use concentric knockouts.

C. Junction boxes, pull boxes, and electrical enclosures larger than 4” (100 mm) trade size in any dimension shall be as follows, unless required otherwise.
   1. NEMA rating for electrical enclosures installed in nonhazardous locations:
      a. Indoor:
         1) Dry environment controlled area: NEMA 12.
         2) Noncorrosive wet or hose-down area: NEMA 4.
         3) Corrosive wet or hose-down area: NEMA 4X
      b. Outdoor:
         1) Corrosive area: NEMA 4X.
         2) Noncorrosive area hose-down or spray area: NEMA 4.
         3) Noncorrosive area nonhose-down area NEMA 3R.
   2. Construct noncast-metal electrical enclosures from reinforced steel plate capable of supporting devices mounted on or within enclosure without deflection. Steel plate thickness shall conform to UL requirements.
   3. Enclosures shall be of adequate strength to support mounted components during shipment and installation.
   5. Electrical enclosures located in outdoor, wet, or hose down areas shall be provided with space heaters. Provide space heaters completely wired within enclosure. Provide following:
      a. Space heater.
      b. Adjustable thermostat with set point temperature indicator.
c. One miniature circuit breaker protective device.

d. Space heaters, thermostat, and protection shall not interfere with cable into or out of enclosure, or with maintenance or replacement of devices within enclosure.

e. Use of space heaters shall not change or discolor any painted surface.

f. Space heater capacity shall maintain enclosure internal temperature above dew point under service conditions for Fairbanks, Alaska.

g. Space heaters: Rate for 240 volts ac minimum, and size for operation on applied voltage of 120 volts ac.

D. Outdoor electrical enclosures with ventilating openings:
   1. Louver on outdoor electrical equipment and protect in accordance with NEMA type.
   2. Equip openings on outdoor electrical equipment with fine mesh filters and stainless steel bug screens.

2.06 OUTLET BOXES

A. Outlet boxes for concealed wiring systems: Sheet metal, galvanized or cadmium plated.

B. Minimum 4” (100 mm) square, 1-1/2” (38 mm) deep, sized to accommodate devices and number of conductors in accordance with NEC. Equip with plaster ring or cover as necessary for flush finish.

C. Exposed conduit systems shall have surface-mounted boxes unless specified otherwise. Boxes for exposed wiring in nonhazardous, noncorrosive, and non-weatherproof locations shall be malleable iron, cadmium finish or cast aluminum alloy, minimum 4” (100 mm) square, 1-1/2” (38 mm) deep.

D. Enclosures shall be as required for areas in which they are installed and as specified.
   1. Boxes: Install flush in masonry construction and design for intended use.
   2. Recessed boxes:
      a. Where fixture is mounted, boxes shall be minimum 4” (100 mm) and octagonal in shape or 4” (100 mm) square by 1-1/2” (38 mm) deep with round plaster ring.
      b. Where used as junction box, boxes shall be minimum 4” (100 mm) square by 2-1/8” (53 mm) deep.

3. Outlet boxes for wall concealed telephone and signaling systems: 4” (100 mm) square by 1-1/2”(38 mm) deep, minimum. Furnish with plaster ring and cover plate.

4. Floor boxes for floor outlets:
   a. Cast-metal with threaded conduit entrances, brass flange ring and brass duplex flap cover plate.
   b. Watertight with leveling and adjustment screws for adjusting cover plate to finished floor.
   c. Minimum 4” (100 mm) diameter and 3-1/2” (88 mm) deep with approved gasket or seal between adjusting ring and box.

5. Floor outlets for combination signaling, data, and power outlets: Construct of steel base, PVC housing, and steel bracket to allow feed through wiring and activation load-bearing support. Box construction shall meet UL 514A requirements.
   a. Entire housing shall be removable for unrestricted access.
   b. Once assembled, PVC housing shall be capable of carrying 6,000 lb (2722 kg) load.
   c. Coordinate outlet requirements with communication system requirements.

6. Floor boxes in 2-hour rated floors shall be secured in cored hole and shall be UL classified and listed for 2-hour rated floors.

2.07 PULL AND JUNCTION BOXES

A. Furnish junction boxes and pull boxes were shown on Drawings, and where necessary to facilitate pulling wires and cables without damage.

B. Above ground boxes shall be formed from sheet steel, with corners folded in and securely welded with inward flange on each of 4 edges.

C. Drill box for mounting and attachment of cover; galvanize after fabrication.
D. Cover: Construct of one-piece galvanized steel and provide with stainless steel round head machine screws.

E. Box and cover shall be made of code gage steel, or heavier if shown on Drawings.

F. Size: Minimum 4-1/2” (113 mm) deep and in accordance with NEC. Use next larger standard size when necessary in accordance with manufacturer standard sizes.

G. Furnish pull and junction boxes without knockouts for field drilling.

H. Enclosures shall be as required for areas in which installed and in accordance with requirements specified.

I. Underground boxes: Specifically design and construct for intended installed location, and be either pre-formed concrete or PVC. Covers shall be capable of withstanding, without failure, type of traffic in general area.

J. If pull and junction boxes are exposed in and around architecturally finished surfaces, paint box to match finish of nearby surfaces, unless indicated otherwise.

K. Bolt-on junction box covers 3'-0" (900 mm) square or larger, or heavier than 25 lb. (11 kg) shall have permanent rigid handles. Covers larger than 3'-0" x 4'-0" (900 mm x 1200 mm) shall be split.

2.08 EQUIPMENT SAFETY GROUNDING

A. Exposed raceway shall be electrically continuous. Conduit and tray shall not be considered to be only ground conductor.

B. Furnish equipment that is part of integral shipping unit or assembly with bare copper ground conductor extending to central ground connection lug. Lug shall be suitable for field connection to local ground. Electrical equipment shall be considered any device that is energized.

C. Single-point ground connections required for proper operation of electronic equipment shall be insulated from equipment safety ground. Such connections shall be extended, using insulated cable, to single insulated termination point suitable for field connection to appropriate ground system.

D. Conduits containing power circuits shall have ground conductor installed inside conduit. Ground conductor shall be bonded to equipment or tray or duct ground at both ends.

E. Provide ground bushing on each conduit containing power circuit. Connect ground bushings together inside enclosure and to enclosure ground lug or ground bus.
   1. Use No. 8 AWG conductor for ground bushings trade size 1-1/2" (38 mm) and smaller.
   2. Ground bushings larger than 1-1/2" (38 mm) shall be sized in accordance with requirements of NEC, but in no case shall bushings be smaller than No. 8 AWG.

F. Ground conductor: Uninsulated, Class B standard, round soft drawn uncoated copper as defined in ICEA S-19-81, unless specified otherwise.

G. Hardware: Clamps, bolts, washers, nuts, and other hardware used with grounding conductor shall be copper, copper alloy, high copper alloy, or silicon bronze.

2.09 PIN AND SOCKET CONNECTORS

A. Unless shown on Drawings, not allowed.

2.10 FUSES AND FUSE BLOCKS
A. Modular-type, Class H screw terminal fuse blocks with Bakelite frame and reinforced retaining clips. Blocks shall be similar in construction and by same manufacturer.

B. Slow blow fuses: Bussmann Type MDL or Gould Shawmut Type GDL with ampere ratings of 1/4, 1/2, 1, or 2.

C. Fast acting fuses: Bussmann Type NON or Gould Shawmut Type OT with ampere ratings of 1, 3, 6, 10, 15, 20, or 30.

D. Extremely fast acting fuses: Bussmann Type KAB with ampere ratings of 1, 3, 6, 10, 15, 20, or 30.

2.11 CONTROL RELAYS

A. General service, industrial grade auxiliary relays rated 600-volt.

B. Contacts: Reversible from N.O. to N.C. in field.

C. Timing relays for critical service: Agastat Series 7000.

2.12 CONTROL SWITCHES

A. Multistage, rotary-type rated 120 volts ac or 125 volts dc, 3 amperes, as required.

B. Handles: Black, fixed, modern, pistol grip type. Provide engraved black plastic escutcheon plates with targets.

C. Provide with colored LED lamps and nameplates as required.

2.13 PUSHBUTTONS

A. Standard pushbuttons: Heavy, industrial-type rated 120 volts ac or 125 volts dc, 3 amperes, as required.

B. Provide with colored LED lamps and nameplates as required.

2.14 INDICATING LIGHTS

A. Status indicating lights: High-intensity, cluster, LED-type for panel mounting.

B. Coordinate indicating light colors with indicated conditions as follows. Indicating lights shall be energized when condition exists and shall be de-energized when condition does not exist:
   1. Red: Equipment energized: such as motor running, valve open, or breaker closed.
   2. Green: Equipment de-energized: such as motor stopped, valve closed, or breaker open.
   3. Amber: Equipment abnormality: such as motor trip, breaker trip, or relay trip.
   4. White: Monitoring of control power or trip coil: such as lockout relay trip coil monitor or breaker trip coil monitor. Light is on during normal circuit operation and off during loss of power or loss of coil.
   5. Blue: Loss of control power.

2.15 ALARM AND TRIP CONTACTS

A. Alarm contacts for remote annunciation: Suitable for operation at 120 volts ac and 125 volts dc. Contacts shall be rated at least 0.5-ampere make and break, minimum.

B. Alarm contacts: Normally closed contacts that open to alarm condition.

C. Trip contacts for remote trip: Suitable for operation at 125 volts dc and rated 5 amperes make or break, minimum.
2.16 SEPARATELY MOUNTED COMBINATION MOTOR STARTERS

A. Enclosed, 3-phase, full-voltage, non-reversing, unless indicated otherwise.

B. Complete combination starter shall have minimum interrupting rating of 65 kA or greater if specified elsewhere or indicated on Drawings.

C. Starter enclosures shall have enclosure NEMA rating specified herein.

D. Provide combination starter with microprocessor-based contactor and integral electronic overload protection; minimum size shall be NEMA 1.

E. Each phase shall have microprocessor-monitored current sensor for motor running overload, phase loss and phase unbalance protection.
   1. Provide Class II ground fault protection; set to 20% of maximum continuous ampere rating and have delay of 20 seconds and run delay of 1 second to prevent nuisance trip on start.
   2. Single-speed starters shall be furnished with 3 current sensors. 2-speed starters shall be furnished with 6 current sensors.

F. Starters shall be furnished with motor circuit protectors (MCP) rated 600-volt.
   1. Each breaker shall be manually operated with quick-make, quick-break, trip-free toggle mechanism.
   2. Starters shall have external manual breaker-operating handle with provisions for up to 3 padlocks.
   4. Access door shall be interlocked with motor circuit protector, so door cannot be opened while breaker is closed except by interlock override.
   5. Starter contactor shall mechanically operate auxiliary contacts. Each starter shall include auxiliary contacts required for application, plus 2 spare NO and 1 spare NC contacts.
   6. Provide membrane-style pushbutton control module and LED lights, if indicated on schematics, to control starter functions and indication. Pushbuttons and LEDs shall be clearly identified.
   7. Verify and match control power transformers, overload protection, and sizes of starters to actual equipment furnished.
   8. Size control power transformers (CPT) to supply control circuit and any additional loading simultaneously. Minimum CPT size shall be 100 volts-amperes for Size 1 starters and 150 volts-amperes for Size 2 and larger starters.
   9. CPTs shall have primary leads protected, and one secondary lead protected and one secondary lead grounded. Provide DIN rail-mounted, miniature circuit breakers for protection. Fuses not allowed.
  10. Starters for systems with system voltage of 120 volts or less shall not require CPT.
  11. Two-speed starters and reversing starters shall be mechanically and electrically interlocked so only one set of contacts can be closed at any one time.

2.17 LOCAL SEPARATE CIRCUIT BREAKERS

A. Provide 3-pole, molded-case, separately enclosed circuit breakers of not less than interrupting rating shown on Drawings at rated voltage.
   1. Provide with thermal and instantaneous trip elements.
   2. Breakers shall use high-conductivity copper for current carrying parts. Breaker enclosures shall have NEMA type enclosure as specified.

B. Each breaker shall be manually operated with quick-make, quick-break, and trip-free toggle mechanism. Thermal elements shall withstand sustained overloads and short-circuit currents without injury and without affecting calibration.

C. Circuit breakers shall have "On," "Off," and "Tripped" indication and shall be pad-lockable with 3 padlocks in "On" and "Off" position.
   1. Breakers rated over 70 amperes shall be rated 100% and have adjustable electronic trip units.
   2. Breakers shall be capable of adding alarm, lockout, shunt trip, and under-voltage as options.
2.18 LOCAL SEPARATE DISCONNECT SWITCHES

A. Three-pole, nonfusible, heavy-duty, rated 600-volt with continuous current rating as shown on Drawings and as required by load.
   1. Type: Either molded-case or blade.
   2. Switches shall use high-conductivity copper for current carrying parts.

B. Switches shall be positive, quick-make, and quick-break mechanisms.
   1. Switch assembly plus operating handle shall be integral part of enclosure base.
   2. Each switch shall have handle whose position is easily recognizable and which can be locked in "On" and "Off" position with 3 padlocks. "On" and "Off" positions shall be clearly marked.

C. Switches shall be UL-listed and horsepower rated. Where applicable, switches shall have defeatable door interlocks that prevent door from being opened while operating handle is in "On" position.

2.19 DC MOTOR STARTERS

A. Magnetic starters for dc service shall be suitable for starting 125 volts dc rated motors unless stated otherwise.

B. Starters shall have same features and capabilities, where applicable, as ac combination and manual starters.

C. Size starters for motor served. Coordinate system requirements with equipment manufacturer’s requirements.

D. Manufacturer: General Electric or Cutler Hammer.

2.20 PLATES AND COVERS

A. Provide finish plates and covers of appropriate type and size for wiring and control devices, signal, and communication outlets.

B. Mark each plate and cover to show circuit and panel designation. Unless indicated to be engraved plate, use self-sticking, clear membrane, UV-resistant labels with typed black letters. Handwritten labels not allowed.

C. Coordinate color with adjacent surfaces.

D. Raised cover galvanized steel plates shall be acceptable for use on surface-mounted outlet boxes in unfinished areas where weatherproof plates are not required.

E. For weatherproof installations, cover plates shall be gasketed and rated for NEMA Type 4 installation.

F. Device plate mounting hardware shall be countersunk and finished to match plate.

2.21 WIRING DEVICES

A. Where more than one flush device is indicated in same location, mount devices in gangs under common plate.

B. Switches for control of ac lighting panel load circuits, single-pole, 3-way, and 4-way, shall be premium, heavy-duty specification-grade, and meet FS W-S-896E. Switches shall be rated for use at 120 or 277 volts and 20 amperes minimum.

C. Device color, if not shown on Drawings, shall be coordinated to match adjacent finishes.

D. Wall switches requiring pilot light indication shall have red LED pilot light when toggled “On.”
E. Pulse control of lighting contactors shall be 20 amperes, 120/277 volts, momentary, double-throw, and center "Off."

F. Standard convenience outlets: Premium, heavy-duty, specification-grade, duplex, 3-wire, grounding, 20-ampere, 125-volt for 120-volt circuits, and rated 250-volts for 240 or 208-volt circuits.

G. Ground fault circuit interrupter (GFI) receptacles: Duplex, 20-ampere, and 125 volts, feed-through type.

H. Isolated ground (IG) outlets: Duplex, 3-wire, with isolated grounding terminal, 20-ampere, and 125 volts. Outlets shall be orange in color, unless specified otherwise.

2.22 WELDING

A. If special welding requirements are required for any piece of equipment during installation, requirements shall be stated on manufacturer's shop drawing of affected part.

B. Furnish detailed welding requirements with equipment shipment.

2.23 PANELBOARDS

A. Dead-front, circuit breaker type, rated for voltage, phase, with main lugs or main breaker as indicated on panel schedules.

B. Enclosure shall be NEMA-rated for installation location and capable of flush or surface mounting.

C. Enclosure cover and access door shall be hinged with breaker operating handles accessible through latchable and lockable door.

D. Typed panel directory located inside door shall have panel and circuits function clearly identified. Handwritten panel schedules not allowed.

E. Provide main and neutral buses insulated from cabinet with separate ground bus. Bus material shall be copper. Ground bus shall be similar to neutral bus in size and number of conductor terminating positions.
   1. Bond ground bus to panelboard enclosure by copper ground strap or copper conductor of appropriate size. Bond neutral bus to ground bus in accordance with requirements of NEC.
   2. Grounding bus connection to enclosure by removable screws not allowed.
   3. Bus shall be capable of terminating clamp type lugs for neutral cable in each supply conduit, and connections for neutral cable in each load circuit.
   4. Neutral bus shall be fully rated, unless specified otherwise.
   5. Isolated ground panelboards: As specified above, except isolated ground bus shall be bonded, by insulated ground conductor, back to source of separately derived system. Do not bond isolated ground bus to panelboard enclosure unless this is first point of grounding for separately derived system.

2.24 CIRCUIT BREAKERS


B. Branch circuit breakers used for lighting circuits shall be switch duty rated, "SWD."

C. Breakers having multiple poles shall be manufactured as common trip type.

D. Interrupting rating shall be not less than interrupting rating of panelboards, and not series rated to achieve required short circuit interrupting rating.
E. Provide handle clips for 10%, or minimum of 2 whichever is greater, for breakers to prevent casual operation. If no breakers are indicated for installation, then provide on breakers labeled as spare.

F. Breakers, and provisions for future breakers, shall be provided in quantities, poles, and ampere ratings shown on Drawings.

G. Molded-case circuit breakers used in ac and dc panelboards and ac load centers shall be bolt-on type, G-frame size.

2.25 FINISHES

A. Manufacturer’s standard coating systems shall be factory-applied. Coating systems shall provide resistance to corrosion caused by weather and industrial environments.
   1. Surfaces inaccessible after factory or field assembly shall be protected for life of equipment.
   2. Painted surfaces shall be filled to provide smooth, uniform base for painting.
   3. Surfaces requiring field welds shall not be coated within 3” (75 mm) of field weld.

B. Coating material and application techniques shall conform to regulations of air quality management agency having jurisdiction.

C. Exterior surfaces of control and electrical equipment, including panels, cabinets, switchgear, transformers, and motors shall be manufacturer’s standard colors unless specified otherwise.

D. Apply high-temperature coating systems to uninsulated equipment operating at temperatures at or above 200°F (93°C).

2.26 RUST-INHIBITOR COMPOUNDS

A. Uncoated machined and ferrous surfaces subject to corrosion shall be protected with rust-inhibitor compounds.

B. Rust-inhibitor compounds used to protect surfaces of equipment and piping exposed to feedwater or steam shall be completely water-soluble.

C. Surfaces to be field welded shall be coated with consumable rust-inhibitor compounds that will not affect quality of weld.

D. External gasket surfaces, flange faces, couplings, rotating equipment shafts and bearings shall be thoroughly cleaned and coated with rust-inhibitor compounds.

2.27 IDENTIFICATION AND TAGGING

A. Conduits inside manholes, hand holes, building entrance pull boxes, and junction boxes shall be provided with 19-gage (1 mm) stainless steel identification tags, with 1/2” (13 mm) stamped letters and numbers.
   1. Attach conduit Identification tags with stainless steel banding. Tag position shall be readily visible for inspection.
   2. Tags shall provide, as minimum:
      a. Circuit origination and destination.
      b. Voltage.
      c. Number of conductors in accordance with phase.
      d. Number of phase conductors.

B. Cables passing through or terminating in manholes, hand holes, and pull boxes shall have 19-gage (1 mm) stainless steel identification tags with stamped lettering that provides circuit identification information.
C. Provide power, control, and instrumentation cables with permanent type identification markers with typed cable numbers and from/to information at each point of termination. Cable numbers and from/to information will be provided for circuits not associated with low-voltage panelboards.
   1. Position cable markers to be readily visible for inspection.
   2. Cable numbers shall match those as shown on Drawings.
   3. Provide wire tags at each termination point for each conductor. Tags shall be permanent, wrap around, heat-shrinkable type with typewritten information.

D. Color-code power conductors with electrical tape or provide with colored jacket.
   1. Source voltage of 208Y/120 volts:
      a. Phase A: Black.
      b. Phase B: Red.
      c. Phase C: Blue.
   2. Source voltage of 120/240 volts:
      a. Phase A: Black.
      b. Phase B: Red.
   3. Source voltage of 480Y/277 volts:
      b. Phase B: Orange.
      c. Phase C: Yellow.
      d. Neutral: Gray.
   4. Source voltage of 240/120-volt delta: High-leg systems shall not be used without Engineer approval.
   5. Service entrance and equipment ground conductors shall be bare copper or green insulated conductor. Equipment bonding conductors shall be bare copper.
   6. Isolated ground conductors shall be insulated; green in color with integral yellow stripe. No substitutions.

E. Signage:
   1. Provide proper signage, plaque, directory and warning labels for electrical equipment and raceway in accordance with NEC requirements.
   2. One-line diagram: Display unfolded and behind clear plastic so diagram is clearly visible.
   3. Mount diagram to permanent structure or wall and located within sight of each feeder, branch-circuit disconnect, each service disconnect, and switchgear. Place permanent legible warning sign in conspicuous location with wording “Danger – High Voltage” required for following areas over 600 volts:
      a. A “Danger – High Voltage” warning sign lettering shall be a minimum of 1” (25 mm) high and remaining lettering a minimum of 1/4” (6 mm) high.
      b. Locations:
         1) At entrances to electrical equipment vaults and electrical equipment rooms, areas, or enclosures, and manholes and handholes, unless words are cast into access cover.
         2) At points of access to conductors on high-voltage conduit systems and cable systems.
         3) On cable trays and cable trench containing high-voltage conductors with maximum spacing of warning notices not to exceed 10’ (3 m).
         4) On metal-clad and metal-enclosed switchgear panels or doors providing access to live parts over 600 volts [a], [Article 225.70].
         5) On isolated phase and nonsegregated phase bus duct, at access openings unless Buyer has a differing standard.

2.28 EQUIPMENT NAMEPLATES

A. Laminated white-over-black plastic such that face is white with black letters, with 1/8” (3 mm) engraved letters securely fastened with minimum of 2 self-tapping, stainless steel screws.

B. Motor starters, either separately mounted or contained in motor control centers, shall have nameplates identifying related equipment. Where separate control and indicating lights are used, starters shall have engraved or etched legends (“start”, "stop", etc.) as shown on Drawings.
C. Provide control stations with nameplates identifying related equipment. Control and indicating lights shall have engraved or etched legends as shown on Drawings.

D. Circuit breakers within main switchboards and distribution switchboards shall be provided with nameplates identifying related equipment being served.

E. Fused and nonfused switches shall have 2 front cover-mounted nameplates.
   1. Nameplate containing permanent record indicating switch type, manufacturer's name, catalog number, and appropriate rating for equipment served.
   2. Provide additional nameplate to identify associated equipment.

F. Panelboards shall have front cover-mounted nameplates identifying panelboard, matching information shown on Drawings and associated panel schedule. Nameplate shall have at least 4 lines of text consisting of:
   1. Line 1: Panel equipment identification number.
   3. Line 3: Appropriate description from which power is derived, (i.e. fed from HP1 through XFMR-LP1).
   4. Line 4: Location of power source, (i.e. PP-1, NW wing).

G. Lighting and auxiliary power transformers shall have front cover-mounted nameplates identifying transformer, matching information shown on Drawings. Nameplate shall have at least 2 lines of text that consist of:
   1. Line 1: Transformer equipment identification number.
   2. Line 2: Location of derived power source (i.e. fed from MDB, Elec Rm Basement).

H. Nameplates shall meet requirements of NFPA 70E

2.29 HARDWARE

A. Provide hardware including, but not limited to, anchor bolts, nuts, washers, expansion anchors, wire nuts needed for installation.

B. Hardware smaller than 3/4" (19 mm) shall match NEMA standard size bolt holes on motors and electrical equipment.

2.30 LOGIC SYSTEMS FACTORY TESTING

A. Prior to shipment, test electrical equipment containing solid-state logic systems in accordance with manufacturer’s standard tests for minimum of 120 hours under power.
   1. Components tested shall include electronic devices; power supplies, input-output devices, operator interface devices, and interconnecting cables provided with system.
   2. System shall be tested as complete assembly. Testing of individual components or modules not allowed as system tests.

B. System test shall include:
   1. Means of confirming logic or mathematical design response of system by simulating changes in system input.
   2. Test shall repeatedly cycle system through operations system will be expected to perform in service with loads on various components equivalent to those which will be experienced in actual service.
   3. Adjustment of power source voltages to high and low limits. Verify correct operation of system at both high and low power source voltage limits.

C. System shall be tested and verified capable of providing surge withstand capability in accordance with requirements of ANSI C37.90.1.

D. Perform tests with solid-state logic system exposed to ambient temperature appropriate to service for which associated electrical equipment is designed.
PART 3 EXECUTION

NOT USED

END OF SECTION

1) D. Akselrod
2) S. Worcester
PART 1    GENERAL

1.01 SECTION INCLUDES

A. Low-voltage, 3-phase, fractional and integral horsepower squirrel cage induction electric motors 1/2 to less than 20 hp.

B. Low-voltage, 3-phase, squirrel cage induction electric motors 20 hp to 450 hp driven by variable frequency drives.

1.02 WORK BY OTHERS

A. Power, control, and grounding connections.

1.03 ACTION SUBMITTALS

A. Shop Drawings:
   1. Complete and accurate Data Sheets.
   2. General description and technical data cut sheets.
   3. Certified outline drawings that include dimensions, weight, lifting points, center of gravity, enclosure construction, and location of accessories.
   4. Recommended long term and short term storage requirements and procedures.
   5. List of recommended start-up and spare parts for each type of motor, including bearings.

1.04 CLOSEOUT SUBMITTALS

A. Manufacturer’s operation and maintenance manuals. Provide, at minimum:
   1. Final reviewed set of drawings listed above.
   2. Operating and maintenance procedures.
   3. Warranty information.

1.05 QUALITY ASSURANCE

A. Manufacturer’s qualifications:
   1. Manufacturer shall manufacture major components of motor and shall be ISO certified.
   2. Manufacturer shall have produced similar equipment for minimum period of 5 years.

B. Regulatory requirements:
   1. Motors shall be in accordance with applicable requirements of NEMA MG-1, NFPA 70, IEEE 112, and UL 1004.
   2. Standards of foreign organizations shall not be used without written approval from Engineer.

1.06 DELIVERY, AND HANDLING

A. During delivery and handle equipment to prevent damage, denting, or scoring.

B. Ship equipment to job Site for installation.

PART 2    PRODUCTS

2.01 MANUFACTURERS

A. Baldor.

B. Ideal Electric.

C. Lincoln Motors.
D. Marathon.
E. Reliance.
F. Siemens.
G. TECO - Westinghouse.
H. Toshiba.
I. U. S. Motors.

2.02 SYSTEM DESCRIPTION

A. Furnish motors either separately or as integral part of mechanical system. Motor horsepower and torque characteristics shall be coordinated with driven piece of equipment by manufacturer.

B. Motor rated power shall exceed driven equipment maximum load by 15% unless otherwise agreed by Owner. Service factor shall not be considered in this calculation.

C. Motors from ½ hp to less than 20 hp are to be started and run from a 480V bus at 60 HZ.

D. Motors from 20 hp to 450 hp are to be driven from adjustable speed drives with a maximum of 480V expected from the drive.

2.03 DESIGN REQUIREMENTS

A. Design equipment in accordance with seismic requirements listed in most recent local building codes and Data Sheets.

2.04 ENCLOSURE SYSTEM

A. Provide totally enclosed fan-cooled motors (TEFC).

B. Bolts and nuts exposed to environment shall be of galvanized steel.

2.05 VOLTAGE AND FREQUENCY

A. Motors shall be capable of operating within design characteristics for system source voltage as specified on Data Sheets.

B. Motors operated from an adjustable frequency drive shall be capable of operating from frequencies of 0 Hz to greater than 60 Hz as required by the Data Sheets.

C. Motors operated from an adjustable frequency drive shall be capable of operating from voltages of 0 V to 480 V as required by the Data Sheets.

D. Design motors for full-voltage, across-the-line starting unless specified otherwise.

2.06 CHARACTERISTICS

A. Torque characteristics shall conform to standard NEMA design letter designation and shall be appropriate for mechanical load served. Motor speed and rotation shall be that required by the driven equipment. Motors shall have torque characteristics adequate to “break away” driven load and to accelerate load to rated speed in length of time that is at least 2 seconds less than the hot locked rotor thermal damage time of motor.

B. Motor locked-rotor current shall not exceed 650% of full load current.
C. Efficiency at rated load shall meet or exceed NEMA Premium efficiency levels.

2.07 MOTOR FRAME

A. Type: Heavy-duty, using cast iron or welded steel construction.

B. Machine sealing parts to high-accuracy to minimize breathing.

C. If specified for hazardous areas, motors shall be enclosed and UL-listed for class, division, and group designation in accordance with NEC Article 500.

D. Motor frame, end brackets, fan covers, drip shields, and bearing housing shall be corrosion-resistant. Motor supporting feet shall be an integral part of frame.

E. Provide motors with stainless steel replaceable automatic drainage fittings. Locate drain holes at low point of motor in final mounted position.

F. Drill and tap for ground lug connection. Locate bolt holes on motor frame, external to, and on same side as terminal box. Provide hole size as follows:
   1. Motors up to 50 hp: 1/4-20 unified inch coarse thread (UNC).
   2. Motors over 50 hp and up to 200 hp: 3/8-16 UNC.
   3. Motors over 200 hp: 1/2-13 UNC.

G. For interchangeability, multiple motors provided as part of same system or on same piece of equipment shall have similar motor frame sizes to minimize number of different frame sizes and associated mounting dimensions.

H. Mount motor on equipment skid and provide provisions for alignment adjustments and belt tightening. Motor shall be factory mounted and aligned to equipment prior to shipment.

I. Provide recommendation for attachment of equipment to foundation or structural supports with design drawings, as applicable. Method of attachment will take into account seismic requirements of job site as indicated on Data Sheets.

2.08 STATOR AND STATOR ASSEMBLY

A. Insulation:
   1. Multiple dips and bakes of insulating varnish.
   2. Where tropicalization is specified on Data Sheets, provide additional dips and bakes of insulating varnish and either use of special insulating materials or varnish treatment to prevent growth of fungus and ingress of moisture.

B. Windings shall be copper.

C. Windings shall be random-wound coils with class of insulation as stated on Data Sheets.

2.09 ROTOR AND SHAFT ASSEMBLIES

A. Motor shaft shall be machined, carbon steel capable of transmitting torque produced by motor.

B. Rotor cage shall be fabricated aluminum, or integrally die-cast aluminum.

C. Rotor shall be epoxy-coated.

D. Dynamically balance motors by one of following means:
   1. Drilling out parent metal in such a manner that structural strength of rotor is not weakened.
   2. Use balance washers securely pinned in place.
3. Chiseling, sawing, or use of solder or similar deposit materials to achieve balance is not acceptable.

2.10 BEARINGS

A. Anti-friction type bearings shall be grease lubricated and have minimum rated life L10 with a median life no less than 50% of L10 life, as defined by ABMA. Reliability of each bearing shall be greater than 90%.

B. Ball bearings shall be vacuum-degassed steel, motor quality.

C. Construct and provide bearing and bearing housing seals to prevent dirt or moisture from entering motor.

D. Provide interior bearing caps or other suitable means to prevent lubricant from entering motor.

E. Integrally cast bearing supports as part of motor end bell. Rabbet end bell to stator assembly to ensure proper bearing alignment and air gap spacing.

F. Design bearings so damage does not occur by axial rotor movement during motor startup and shutdown.

G. Shaft and bearings for belt-connected motor shall withstand normal belt pull of equipment furnished and momentary and continuous overloads due to acceleration caused by incorrect belt tension.

H. Bearings for motors driving vertical pumps, including in-line pumps, shall be designed to carry 200% of maximum thrust, up and down, that pump develops during starting and stopping, and while operating at any capacity on rated performance curve.
   1. Minimum momentary up-thrust capacity shall be equal to 30% of down-thrust at rated capacity.
   2. Thrust bearings for in-line pump motors shall be the motor non-drive end bearing.

I. Motors rated 100 hp and above for non-VFD applications shall have non-drive end bearing insulated to prevent against circulating shaft current.

J. Motors operated from an adjustable speed drive shall have non-drive end and drive end bearings insulated to prevent against circulating shaft current.

K. Motors shall have metallic bearing isolators on each bearing.

L. Furnish vertical motors coupled to vertical pumps with non-reversing ratchets and bolted couplings with case drip shields.

2.11 LUBRICATION SYSTEM

A. System shall be capable of operating at least 8,000 hours without requiring addition of grease or complete change of grease.

B. Provide system with readily accessible grease inlet and outlet plugs in bearing housings to enable regreasing while motor is in service.

2.12 FANS

A. Fan material shall be nonsparking bronze alloy or conductive plastic. Aluminum, bronze, copper, or copper alloy not acceptable.

2.13 SPACE HEATERS
A. Provide low surface-temperature space heaters for motors installed outdoors, and motors rated 25 hp or larger installed indoor or outdoor. Mount on inside of motor frame or winding end turns.

B. Sheath temperature at 110% of rated voltage, when operating at ambient temperature, shall not exceed 200°C or cause motor insulation temperature to exceed 130 °C, whichever is more restrictive.

C. Space heaters shall be rated and designed to operate at voltages as specified on Data Sheets. Space heaters shall be suitable for installation in hazardous areas as defined by NFPA, if motor is specified to be installed in a hazardous area.

D. Route space heater power leads to dedicated terminal box for control and space heater leads.

2.14 MOTOR TERMINAL BOXES

A. Equip each motor with terminal boxes.

B. Size motor lead terminal box to allow for bending radius and stiffness of motor supply cables, and for terminating grounding conductor.
   1. Frame size 445T and below: Cast iron terminal box shall be at least twice usable volume specified in NEMA MG-1, and not less than 24 in³ (393.3 cm³).
   2. Frame size exceeding 445T: Cast iron, cast steel, or steel plate terminal box sized according to NEMA MG-1, Figure 20-3.

C. Motor leads shall have brass or stainless steel ferrules embossed with appropriate lead number, or leads imprint with lead number. Tagging of main leads shall be in accordance with MG-1, Part 2.

D. Fit motor terminal box with neoprene gaskets.

E. Main terminal boxes shall be capable of rotation in 90° increments to permit connection on any one of four sides.

F. Provide motor lead seal and separator gasket between motor frame and terminal box.

G. Provide main terminal boxes with threaded conduit entrances.

H. Motor leads shall have oil-resistant insulation.

I. Terminate main lead electrical connections with tinned lugs.

2.15 IDENTIFICATION AND TAGGING

A. Securely attach embossed or stamped, stainless steel nameplates with stainless steel screws or pins.

B. Nameplate shall contain standard information in accordance with NEMA MG-1 40.1 and as follows:
   1. Year of manufacture.
   2. Type of bearing lubricant and specification number.
   3. Arrow indicating direction of rotation for main lead connections.
   4. Bearing type and manufacturer’s part number.

C. If identification number cannot be included on motor nameplate, provide separate stainless steel equipment identification nameplate in accordance with equipment identification as provided by Owner.

D. Motor power and space heater circuits may be derived from different sources. Covers of motor terminal boxes containing space heater leads shall be provided with nameplate reading: “ISOLATE MOTOR AND HEATER CIRCUITS BEFORE REMOVING COVER”.

2.16 VARIABLE SPEED MACHINES

Rev. 0
A. Motors defined on the Data Sheet for variable speed application shall be inverter duty rated and operated over the speed range defined.

B. Motors intended for variable speed application shall conform to NEMA MG-1, Part 31.

C. Provided motors with external cooling fans to force cool the machine if the operational speed range defined on Data Sheet reduces integral fan performance below required levels to maintain maximum temperature rise.

D. Electrically insulate both drive end and non-drive end bearings.

PART 3  EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer’s recommendations.

END OF SECTION

1)D. Akselrod
2)S. Worcester
PART 1    GENERAL

1.01 SECTION INCLUDES

A. Low-voltage variable frequency drive (VFD) designed for use on 3-phase squirrel cage induction motor.

1.02 ACTION SUBMITTALS

A. Drawings:
   1. Certified outline, general arrangement, assembly, and installation drawings, that includes front view, dimensions, and weight.
   2. Elementary diagrams (3-line diagrams) and schematic control diagrams of complete VFD system showing terminal block terminations, device terminal numbers and internal wiring diagrams.
   3. Certified drawings of cable termination compartments showing preferred locations for conduit entry/exit locations and indicating space available for cable terminations.

1.03 CLOSEOUT SUBMITTALS

A. Operation and maintenance manuals. Refer to section 01 78 23. Provide, at minimum:
   1. Final copies of documents listed above.
   2. Operating and maintenance procedures.
   3. Spare parts lists with pricing.
   4. Installation field reports and Data Sheets updated to reflect field installation conditions
   5. Copies of warranty.

1.04 QUALITY ASSURANCE

A. Design and manufacture according to latest editions of applicable NEMA, UL, NFPA, IEEE, and ANSI standards.

B. Manufacturer shall be ISO 9001 certified and shall have produced similar electrical equipment for minimum period of 5 years.

C. When requested by Engineer, provide acceptable list of similar equipment installations complying with requirements of this specification.

D. Completed drive shall be tested for at least 3 hours with induction motor connected.

1.05 DELIVERY, STORAGE, AND HANDLING

A. During delivery and storage, handle equipment to prevent damage, denting, or scoring.

B. Store equipment and components in clean, dry place. Protect from weather, dirt, water, construction debris, and physical damage in accordance with manufacturer’s instructions.

1.06 REDUNDANCY

A. Provide two identical (redundant) VFDs for any single-redundant piece of major equipment requiring variable speed drives. This includes, but is not limited to, the following: Primary Air Fans, Secondary Air Fans, Induced Draft Fans.

PART 2    PRODUCTS

2.01 MANUFACTURERS
2.02 SYSTEM DESCRIPTION

A. VFD shall convert incoming fixed frequency 3-phase ac power into variable frequency and voltage for controlling speed of 3-phase ac motor.

B. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for eliminating need for motor derating.

C. VFD shall be sinusoidal PWM type drive with sensor-less torque vector control capability. Control techniques other than PWM, not acceptable.

D. Components:
   1. Full-wave diode rectifier to convert supply ac to fixed dc voltage. Minimum 18 pulse rectifier.
   2. Dc link capacitors.
   3. Insulated Gate Bipolar Transistor (IGBT) power section, dual rated for either variable or constant torque applications.
   4. VFD shall be microprocessor-based with LED and LCD display to monitor operating conditions.
   5. Separate control and power terminal boards.

E. VFD shall be of modular construction for ease of access to control and power wiring, and maintenance.

F. Provide in NEMA 1 enclosure for use in normal, nonhazardous industrial environment.

G. Enclosure doors shall include electromechanical interlocking system with safety switch and electrical interlocks tied to main breaker. Whenever doors are open, safety ground switch shall connect plus, minus, and neutral dc buses to ground to ensure stored energy is discharged.

2.03 DESIGN REQUIREMENTS

A. Where manufacturer determines an input drive transformer, input filter, or output filter is required to meet installation requirements, they shall also be provided.

B. Point of Common Coupling (PCC) shall be defined as terminals on input side of circuit breaker directly feeding each individual drive.

C. Total Harmonic Distortion (THD) at each PCC shall not exceed 5%, as recommended for General Systems as listed in Table 10.2 of IEEE Standard 519.

D. Harmonic current distortion at PCC shall not exceed limits listed in Table 10.3 of IEEE Standard 519.

E. Design drive to provide 50,000 hours mean time between failures (MTBF) when specified preventative maintenance is performed.

F. Design motors furnished to meet NEMA MG1, Part 31 for VFD service.

G. Symbols shall conform to ANSI Y32.2/IEEE 315/CSA Z99.

H. Printed circuit boards shall be completely tested and burned-in, in accordance with UL347A before being assembled into completed VFD.

I. Design equipment in accordance with seismic requirements listed in most recent local building codes and Data Sheets.
2.04 MECHANICAL CONSTRUCTION

A. Provide recommendation for attachment of equipment to foundation or structural supports with design drawings, as applicable. Method of attachment will take into account seismic requirements of job site as indicated on Data Sheets.

2.05 INPUT POWER

A. System shall be capable of maintaining rated torque and speed with bus voltage deviations of ±10% and frequency deviations of ±5%.

B. Line notching, transients, and harmonics on incoming line shall not affect VFD performance.

C. Below 70% bus voltage, motor will be allowed to coast. If bus voltage is restored within 2 seconds, system can be started, if selected. If bus voltage is not restored within 2 seconds, system shall be automatically shut down. Automatic or manual restart shall be selectable from control panel.

D. VFD shall have provisions for input line reactor to be incorporated into VFD enclosure.

E. Drive efficiency shall be 95% or higher at rated load.

2.06 OUTPUT POWER

A. Operating mode:
   1. Frequency at 60 Hz and below: Constant volts per Hz mode.
   2. Above 60 Hz: Selectively operate in either constant volts per Hz mode or constant voltage extended frequency mode.

B. Rated output voltage: Programmable for either 80 to 240 volts or from 320 to 480 volts depending on 3-phase motor nameplate rating.

C. VFD shall be capable of minimum of 110% of rated full-load current in continuous operation, in accordance with NEC Table 430.150.

2.07 OPERATING RANGE

A. Speed range: 6 to 60 Hz. Both minimum and maximum speeds shall be field-adjustable.

B. VFD shall not have electrical resonance within operating speed range.

C. VFD shall be able to speed search and immediately pick up spinning motor in either forward or reverse direction.

2.08 TORSIONAL REQUIREMENTS

A. VFD, motor, and equipment load shall not develop adverse speed dependent oscillations.

2.09 NOISE

A. Drive shall not cause motor audible noise to increase more than 3 dB at 3' (1 m) above rated noise level for operation on full voltage starter.

2.10 MINIMUM DISPLACEMENT POWER FACTOR

A. PF 0.90 lagging, or higher, at any speed or load without use of power factor correction capacitors.

2.11 HARMONICS MITIGATION
A. Provide output filters or line reactors, as required, such that motor insulation will not be damaged.

B. If additional equipment is necessary to meet IEEE 519 requirements, it shall be through use of one or more of following:
   1. Input isolation transformer.
   2. Input line reactor.
   3. Input harmonic trap filter with series reactor.
   5. Mirus filter.
   6. Dc link reactor.

C. Drive manufacturer shall select and approve equipment provided.

2.12 DRIVE CONTROL

A. VFD shall use control strategy that maximizes efficiency, performance, and power factor while minimizing motor heating.

B. Drive regulator and control: Digital microprocessor design with following functions:
   1. Speed regulation.
   2. Current regulation.
   3. Load angle regulation.
   4. Drive protection.
   5. Drive diagnostics.

C. VFD regulator and control functions shall be stored on nonvolatile memory.

D. Drive shall have minimum of 3 programmable prohibited frequency ranges with adjustable span of 0 to 10 Hz.

E. Provide drive with local and remote controls:
   1. Locate 2-position maintained switch on front of enclosure for selection of “Local” or “Remote” control.
   2. Individual momentary buttons for “Local,” “Start,” and “Stop.”
   3. Speed reference potentiometer.

F. Operation:
   1. Switch in “Local” position: Drive shall operate at speed set by potentiometer when local “Start” button is pushed. “Stop” button shall stop equipment without delay.
   2. Switch in “Remote” position: Drive shall be remotely controlled. Local potentiometer, “Start” button, and “Stop” button shall have no effect on operation.
      a. Speed control shall regulate motor speed corresponding to remote speed signal.
      b. When incoming signal is varying, rate of change of motor speed shall be limited by pre-selected acceleration/ deceleration rate.
      c. Drive shall be programmable to either run at constant speed as determined by minimum speed setting, last signal, preset speed, or to shut down, upon loss of speed signal. Remote speed signal falling below lower limit of range shall also be considered as loss of speed signal. Loss of remote speed signal shall be alarmed.
      d. If remote speed signal is above range upper limit, drive shall run at speed corresponding to upper limit.
      e. Alarms and indication:
         1) Loss of remote speed signal shall be alarmed.
         2) Drive failure alarm.
         3) Drive fault alarm.
         4) Drive in remote and local control indication.
         5) Drive running indication.
G. Following shall be available locally either on control panel display or by use of readouts and LEDs, and remotely through communication interface:
   1. Drive ready.
   2. Drive running.
   3. Current, amps.
   4. Line-line voltage, volts.
   5. Output horsepower, hp.
   6. Speed, rpm.
   7. Frequency, Hz: Digital readout.
   8. Drive alarm conditions.
      a. Missing run or start permissive.
      b. Low control voltage.
      c. Microprocessor problem.
      d. I/O addressing problem.
      e. Loss of speed reference.
      f. Common trouble alarm.
   9. Drive fault conditions requiring immediate attention, and may indicate impending shutdown of drive.
      a. Source undervoltage.
      b. Source overvoltage.
      c. Source loss of phase.
      d. Source reverse phase sequence.
      e. Load overcurrent.
      f. Overspeed.
      g. Ground fault.
      h. Dc Link overvoltage.

H. Provide communications interface for remote monitoring and control of VFD using DeviceNet communications protocol.

2.13 DRIVE DIAGNOSTICS

A. Provide comprehensive diagnostics for maintenance and troubleshooting including:
   1. Self-test of microprocessor drive control system.
   2. LED indicators for status indication on control boards.
   3. Convenient maintenance test points.

2.14 COOLING

A. Provide integral filtered ambient air cooling by natural convection or forced air cooling system as required to maintain drive equipment at its full current rating.

2.15 IDENTIFICATION AND TAGGING

A. Securely attach nameplates with self-tapping stainless steel screws. Adhesive nameplates not acceptable.

B. Lettering shall be black on white background.

PART 3 EXECUTION

NOT USED

END OF SECTION

1) D. Akselrod
2) S. Worcester
PART 1  GENERAL

1.01  SECTION INCLUDES

A. Minimum requirements for allowable reaction loads at equipment piping connection interface for:
   1. ASME pressure vessels.
   2. Heat exchangers (plate and frame)
   3. Tanks

B. Requirements for deviation from minimum allowable reaction load requirement.

C. Submittal requirements of allowable reaction loads.

1.02  DEFINITIONS

A. Equipment reaction loads: Piping reaction forces and moments applied at equipment piping interface connection.

B. Reaction coordinate system: Coordinate system of allowable reaction loads using either pipe local coordinate system (axial, longitudinal), or equipment coordinate system (i.e. turbine shaft is +X, +Y is up, and +Z is cross product of +X and +Y).

1.03  MINIMUM ALLOWABLE REACTION LOADS

A. Following equipment shall meet or exceed minimum allowable reaction loads:
   1. ASME pressure vessels.
   2. Heat exchangers (plate and frame)
   3. Tanks

B. Minimum allowable reaction loads:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2&quot; and Smaller</td>
<td>400</td>
<td>360</td>
<td>340</td>
<td>320</td>
</tr>
<tr>
<td>2 1/2&quot;</td>
<td>500</td>
<td>450</td>
<td>520</td>
<td>480</td>
</tr>
<tr>
<td>3&quot;</td>
<td>600</td>
<td>540</td>
<td>700</td>
<td>650</td>
</tr>
<tr>
<td>4&quot;</td>
<td>800</td>
<td>720</td>
<td>980</td>
<td>900</td>
</tr>
<tr>
<td>5&quot;</td>
<td>1400</td>
<td>1260</td>
<td>1700</td>
<td>1570</td>
</tr>
<tr>
<td>8&quot;</td>
<td>2200</td>
<td>1950</td>
<td>2600</td>
<td>2350</td>
</tr>
<tr>
<td>10&quot;</td>
<td>3000</td>
<td>2700</td>
<td>3700</td>
<td>3370</td>
</tr>
<tr>
<td>12&quot;</td>
<td>3600</td>
<td>3300</td>
<td>4500</td>
<td>4120</td>
</tr>
<tr>
<td>14&quot;</td>
<td>4000</td>
<td>3600</td>
<td>4700</td>
<td>4200</td>
</tr>
<tr>
<td>16&quot;</td>
<td>4600</td>
<td>4200</td>
<td>5400</td>
<td>4830</td>
</tr>
</tbody>
</table>

1 Longitudinal force acts separately in two directions, refer to Figure 1; allowable shown in table above is for individual direction.

2 Bending moment is about each Longitudinal Force direction, refer to Figure 1; allowable shown in table above is for an individual moment.

3 For pipe sizes larger than those found in table, submit items required in accordance with article “Action Submittals.”

1.04  DEVIATION FROM MINIMUM ALLOWABLE REACTION LOADS

A. If Seller cannot meet minimum allowable reaction loads for an individual piping connection, provide:
   1. Revised allowable reaction loads (forces and moments) for individual piping connection.
   2. Calculated translational and rotational stiffnesses in each direction for individual piping connection.
   3. Figure detailing coordinate system of revised allowable reaction loads.
B. If Seller exceeds minimum allowable reaction loads for an individual pipe connection, manufacturer must submit:
   1. Revised allowable reaction loads for individual piping connection.
   2. Figure detailing coordinate system of revised allowable reaction loads.

1.05 ACTION SUBMITTALS

A. Shop Drawings:
   1. Detailed figures of allowable reaction loads coordinate system.
   2. Allowable reaction loads.
   3. Translational and rotational stiffnesses, if required.
   4. Displacements of connection nozzle at design temperature of piping and equipment.
   5. Design Data: Computations for allowable reaction loads, displacements, and transverse and rotational stiffnesses shall be made available for review at the Sellers offices, if requested by the Buyer.

![Figure 1: Force and Moment Diagram](image)

PART 2 PRODUCTS
NOT USED

PART 3 EXECUTION
NOT USED

END OF SECTION

1) M. Jahn
2) J. Solan
PART 1    GENERAL

1.01    SECTION INCLUDES

A. Pipe, fittings, accessories, and appurtenances.

B. Pipe, fittings, valves, and accessory material as necessary for complete piping system with connections to equipment including drains required to drain low points in piping and vents required to vent high points in piping, piping for testing, startup, cleaning, and operation of system.

C. Pipe, fittings, valves, and accessory material necessary for following piping:
   1. Vents and drains for equipment to which piping connections are made or which are furnished under this Contract; provide piping to drains from float cages, level alarms, meter bodies, transmitters, steam trap blow connections, etc.
   2. Piping required for proper operation of piping system and equipment, including drain valves required to drain all low points in piping and vent valves required to vent all high points in piping for testing, startup, and operation.
   3. Metering instruments and regulating apparatus, including pressure gages, thermometers, controllers, traps, and other appurtenances as required for satisfactory operation of piping system and proper functioning of such instruments and controls.
   4. Flanges, unions, bolting material, gaskets, reducing fittings, bushings, and adapters required to connect piping to equipment, valves, in line specialties, etc.
   5. Temporary piping and accessories required for placing equipment and piping into initial service; temporary piping will include, but not be limited to, interconnecting and vent lines required for pipe line cleaning, and hydrostatic testing. Arrangement of piping and supports shall be submitted to Buyer.
   6. Blind flanges, caps, or plugs of appropriate class to close unused openings in equipment.

1.02    DESIGN REQUIREMENTS

A. Piping arrangement:
   1. Shop fabricate all piping to the greatest extent possible.
   2. Protection of electrical equipment: Coordinate piping design with Buyers General Arrangement drawings. Avoid locating joints, specialties, valves, etc., over electrical equipment. Piping shall be kept from dedicated electrical space and working space as defined by NFPA 70.
   3. Locate reducers for equipment connections, valves, etc., at equipment or valves to minimize length of reduced diameter piping.

B. Equipment arrangement:
   1. Boiler island equipment described herein is generic in nature. Equipment not applicable to Seller's unit may be omitted. Equipment which is applicable shall conform to requirements specified.
   2. Equipment or systems which are not specified herein, but are integral and inherent to Seller's design, shall be furnished.

1.03    SUBMITTALS

A. Drawings:
   1. Piping and Instrumentation Drawings (P&IDs)
   2. Detailed piping drawings, including:
      a. Isometric or spool drawings
      b. Plan, section, and detail drawings

B. Lists
   1. Data should be provided in electronic document format (PDF) and in a format that can be easily imported into a plant information database (Excel, Access database, or similar).
   2. Pipeline list, containing the following at a minimum
      a. Pipeline identification number (pipeline number)
      b. Piping material identification code.
c. Pipe material and schedule or wall thickness, as applicable

d. Flange types, facings, and pressure ratings.

e. Identification of pipe service.

f. Service conditions (nominal operating).

g. Design conditions

h. Test pressure

i. Cleaning requirements

j. Coating requirements

k. Insulation thickness or class

l. P&ID references

3. Valve List in accordance with the requirements listed in 40 05 23 – General Duty Process Valves and Accessories

4. Piping Specialty List

5. Pipe Support List

C. Drawing Requirements:

1. Each drawing shall include as much of piping system as is feasible for clarity.

2. Each drawing shall include unique identification numbers for all equipment, pipelines, valves, and piping specialties.

3. Piping drawings shall contain the following information, as applicable:
   a. Overall dimensions.
   b. Location of nozzles, taps, supporting lugs and other pipe attachments.
   c. Location of field welds.
   d. Identification mark number for each spool of pipe.
   e. Individual spool sheets for each mark number: For erection and assembly information only.

D. Quality assurance data:

1. Certificates of compliance with standards specified for pipe, fittings, accessories, and specialties.

2. Shop pressure test certifications within 7 days of test.

3. Shop pressure test packages for all systems prior to tests. Package shall include, as a minimum, piping and instrumentation diagrams indicating test boundaries, test pressure, test media, and test length.

4. Pipe stress analysis and code compliance reports for steam piping. Submit supporting isometric drawing(s) which provide the following:
   a. Identification of pipe system.
   b. Pipe material and wall thickness.
   c. Design pressure and temperature.
   d. Overall dimensions.
   e. Location of supports, anchors, guides, and pipe attachments.

5. Piping mill certification test records prior to pipe fabrication.

6. Welding procedure specifications 30 days prior to start of welding.

7. Welding procedure qualification test records 30 days prior to start of welding.

8. Welder qualification test reports upon request.


10. Calibration reports prior to system commissioning.

11. Test reports:
   a. Submit complete reports covering Sellers interpretation of test findings and their disposition.
   b. Each test report shall include data identifying each item, material, test method, test number, date of test, Sellers name, Contract number, and Buyers name and station identification.

12. Partial data reports:
   a. "Manufacturer's Data Form for Fabricated Piping," Form P-4A, (partial data reports) and inspection and stamping for piping and fittings fabricated in conformance with Section I of ASME "B&PV Code".
   b. Submit with shipping papers.

E. Closeout submittals:

1. Project Record Documents:
   a. Startup records within 14 days of startup.
b. O&M Manuals in accordance with the requirements of Section 01 78 23 – Operating and Maintenance Data.

1.04 QUALITY ASSURANCE

A. Regulatory requirements:
1. Welding materials and procedures for piping within the limits of the B&PV code shall be in accordance with the code.
2. Welding materials and procedures for piping outside the jurisdictional limits of the B&PV code shall conform to ASME B31.1, "Code for Pressure Piping – Power Piping," and applicable state regulations.
3. Employ certified welders in accordance with Section IX ASME B&PV Code and AWS D1.1.

1.05 DELIVERY, STORAGE AND HANDLING

A. All piping shall be prepared for shipment in accordance with the following minimum requirements.
B. Piping packaging shall be suitable to protect the piping from damage or corrosion during shipment via oceangoing vessel.
C. Pipe spools shall contain piece identification mark on each end of spool.
D. Weld end larger than 2": Fit pipe with protective end caps lined with 3/4" soft wood to prevent damage to machined ends. Seal with waterproof tape.
E. Female opening 2" and smaller: Install plastic insert and seal with waterproof tape.
F. Nonflanged nipples 2" and smaller: Fit pipe with plastic cap and seal with waterproof tape.
G. Flanged opening: Bolt 1/2" waterproof disk with 1/8" rubber gasket. Use at least half available holes.

PART 2 PRODUCTS

2.01 PIPE MATERIALS

A. Piping shall comply with ASME B&PV Code and, where applicable, ASME B31.1.
B. Pipe materials: As required for service.
C. Pressure class and type of joints: As required for service.
D. Piping and fittings shall be seamless.
E. Piping material shall be new. Materials showing signs of scaling or rust will be rejected.
F. Pipe material and pressure class of main line shall also apply through isolating valves at main line for instrument, controls, instrument air, and sample connections. Use instrument and sample tubing materials and fittings only between isolating valves at main line or equipment and instruments or controls.
G. Provide carbon steel feedwater piping with minimum incidental chromium content of 0.1% as documented by mill certification test record for feedwater piping, including superheater and desuperheater supply piping.

2.02 BOLTS AND NUTS

A. Material:
1. Weld neck flanges: Alloy steel
2. Slip-on and flat faced flanges: Carbon steel
3. Materials shall conform to applicable codes and standards

B. Assembly
1. Bolt diameter of 1 ¾ inches (45 mm) and larger: threaded stud and 2 nuts
2. Bolt diameter less than 1 ¾ inches: threaded stud and 2 nuts or bolt and nuts.
3. Bolts for CL 300 flanges or greater: threaded stud and 2 nuts

C. Class of thread fit: As required by applicable codes.

2.03 FITTINGS

A. Use long radius fittings, except where space limitations require use of short radius fittings.

B. Use welding tees for socket-welded piping and for branch tees in butt welded piping, except as noted on Mechanical Standard M-2099.

C. Mitering of pipe to form elbows, notching straight pipe to form tees, and similar construction will not be acceptable for pressure piping.

D. Butt weld end preparations:
1. Nominal pipe wall thickness 0.375" and less: Conform to ASME B16.25, Figure 2, Detail (a).
2. Nominal pipe wall thickness greater than 0.375": Conform to ASME B16.25, Figure 5 or 6.
3. Comply with above unless otherwise required by code.

2.04 DIELECTRIC FITTINGS

A. Install at connections of dissimilar piping materials to prevent current flow.

B. Epco dielectric union with "Epconote" No. 2 gasket or equal.

2.05 PIPE AND DUCTWORK MARKERS

A. Comply with ANSI A13.1.

B. Type: Self-sticking markers indicating contents of pipe and pipe line identification number.

C. Pipe and ductwork marker locations:
1. Each 20' interval on long continuous lines.
2. At each valve, change of direction, branch take-off, and pipe terminal.

D. Lettering:
1. Size: Use 1-1/4" high letters for pipes with outer covering 2-1/2" diameter or larger; use 3/4" high letters for pipes with outer covering smaller than 2-1/2".
2. Lettering subject to review.

E. Color code: ANSI Standard.

F. Banding:
1. Type: Self-sticking tape, 2" wide; with direction flow arrows.
2. Color code: To be furnished after award of Contract (in accordance with BUYERS' system).

G. Manufacturer: Duramark System by Craftmark, or equal.

2.06 PIPING NOZZLES

A. Type: as indicated on Mechanical Standard M-2099 – Reducing Fittings for Branch Pipe Connections or as required herein.
B. Branch connections in shop-fabricated piping for pipe up through ASME Class 150: Nozzle welds or Bonney Forge "Weldolets" or equal.

C. Pipe above ASME Class 150: Use of "Weldolets" limited to 4" diameter pipe branches or 50% of main run pipe diameter, whichever is smaller.

D. Other branch connections: Tees.

E. Existing piping or piping which has previously been fitted and welded in place: Nozzle welds or "Weldolets" not permitted.

F. Upon request, submit to Buyer supporting calculations for branch connections as required by ASME B31.1 "Code for Pressure Piping."

G. Cut nozzle holes in pipe to obtain accurate fit.

H. Use shaped nozzle branches cut to fit contour of pipe hole.

I. Branch connections projecting inside pipe will not be accepted.

J. Fit nozzles to assure alignment with main piping.

K. Reinforce nozzle welds as required to provide joint at least equivalent in strength to bursting strength of straight pipe, as determined by formulas specified in ASME B31.1 "Code for Pressure Piping."

L. Shop Fabricated Branch Fittings:
   1. Shop fabricated branch fittings shall not be used in lieu of integrally reinforced branch fittings or welding tees unless specifically approved by the Buyer on a case by case basis.
   2. When approved by the Buyer, design and fabricate shop fabricated branch fittings in accordance with the applicable sections of ASME B31.1, including Section 104.3.1(C).

2.07 PIPE FLANGES

A. Unless otherwise specified, flanges shall be as follows:
   1. Flanges connecting with adjoining flanges on piping, valves, or equipment shall have the same dimensional characteristics including size, drillings, and facings.
   2. Flanges shall be rated to withstand the design temperature and pressure of the service in which they are being used.
   3. Flange material shall be equivalent to the pipe on which it is being used.

B. Flange types:
   1. All Class 150 flanges that are 2 ½ inches (65 mm) and larger shall be of the weld neck or slip-on type.
   2. All flanges rated as Class 300 or higher that are 2 ½ inches (65 mm) and larger shall be of the weld neck design.
   3. All flanges that are 2 inches (50 mm) and smaller shall be socket type.

C. Flange facings:
   1. All flanges shall have raised faces unless the flange is connecting to cast iron, ductile iron, PVC, CPVC, or HDPE flanges.

2.08 UNIONS

A. Unions not allowed without written approval from Buyer.

2.09 GASKETS

A. Gaskets containing asbestos are not acceptable.
B. Spiral wound gaskets shall be used for all raised face flanges other than slip-on flanges

C. Compressed fiber gaskets shall be used for slip-on raised face flanges and flat face flanges.

D. Compressed fiber gaskets:
   1. Shall be suitable for the working fluid
   2. Minimum rating of 600 psig and 750 deg. F
   3. Size
      a. Flat face flanges: full faced
      b. Raised face flanges: diameter to extend to inside edge of bolt holes
   4. Thickness
      a. Plain finished surfaces: 1/16 inch (1.6 mm)
      b. Serrated surfaces: 3/32 inch (2.4 mm)

E. Spiral wound gaskets
   1. A continuous stainless steel ribbon wound into a spiral with non-asbestos filler between adjacent coils.
   2. Provide with steel gauge ring
      a. To assist with proper positioning of the gasket between the bolts
      To limit the compression of the gasket to the proper value

2.10 BACKING RINGS

A. Backing rings not allowed without written approval from Buyer.

2.11 PIPE BENDS

A. Cold pipe bending not allowed without written approval from Buyer.

2.12 TAPS

A. Make tapped or socket weld piping branches, 2" in size and smaller by using Bonney Forge "Sockolets" or "Thredolets," or equal.

B. Make taps in main piping before piping is fitted in place. No burning of holes permitted after piping is fitted.

C. Make taps for test thermometer wells in top of or 45º either side of vertical for horizontal runs of piping; locate to permit convenient accessibility.

D. Locate taps and space so installation of thermometer wells, thermocouple wells, pressure taps and flow meter differential pressure taps, etc., will not interfere with each other.

E. Locate wells, sampling nozzles, flow nozzles, etc., so stream of flowing fluid passing through or around each device will not be turbulent as result of passing through or around device located upstream.

F. In general, do not locate wells and/or sampling nozzles closer than 10’ in same plane, nor closer than 2 pipe diameters in planes separated by 45º or more.

G. Locate pressure taps upstream of temperature taps.

H. Make socket-weld piping branches as specified.

2.13 PROVISIONS FOR PIPE EXPANSION

A. Provide bends, offsets, or loops in piping as required to permit pipe expansion due to temperature change and equipment movement.

B. Provide sufficient flexibility in copper piping to eliminate stress transmission to fixtures.
C. Refer to Section 3418.40 05 29 for additional pipe expansion and support requirements.

2.14 SLEEVE SEALS

A. Furnish and install sleeve seals between sleeve and piping when penetrating exterior walls and floors.

B. Manufacturer: Thunderline Corporation “Link-Seal,” or equal.

2.15 ACCESS AND MAINTENANCE AREAS

A. Piping shall be designed to facilitate access for maintenance, cleaning, and operation of power plant. Piping shall not impede these functions for any part of plant.

B. Provide space for component removal (where required), maintenance, and access to equipment.

2.16 PIPE FABRICATION

A. Shop-fabricate all piping supplied under this contract.

B. Fabricate pipe in largest sections practicable for shipping and field assembly in an effort to minimize field labor.

C. Use minimum of field-welded joints in shop-fabricated pipe.

D. Field fabrication of piping 2" and smaller may be permitted if approved by Buyer.

E. Field fabrication of boiler code piping is not permitted except as required to assemble shop fabricated piping spools. Shop-fabricate supporting lugs, taps, and other piping attachments and stress relieve, if required, with piping. Include means of insulation support for vertical runs of piping in accordance with Sellers standard insulation support design.

F. Interior cleaning:
   1. Piping and fittings in contact with cycle related water or steam: At a minimum, grit blast to white metal in accordance with SSPC-SP5 and cleaned out with oil free air. Do not use silica-bearing grit.

   2. Piping and fittings in contact with lube oil: Clean and pickle regardless of pipe size:
      a. Clean pipe mechanically by brushing and scraping off dirt, grease, and other undesirable foreign matter. Petroleum solvent may be used if desired, but is not required.
      b. Clean pipe thoroughly in hot caustic bath. Operation shall continue until all dirt, grease, and paint are removed.
      c. Remove pipe from caustic solution and immediately place in acid picking bath. Time in acid pickling bath as required to remove scale and rust and result in clean, bare metal.
      d. Remove pipe from acid pickling bath and immediately wash thoroughly with clear, cold water.
      e. As soon as pipe is thoroughly washed and all traces of acid are removed, and without allowing it to dry, coat immediately with oil. Coating may be satisfactorily done by filling pipe with coating oil, making sure that no air pockets exist which will prevent thorough and complete coating.
      f. Immediately after coating with oil, close ends of pipe spools with metal caps.
      g. Certify in writing that procedure was followed. Submit certification to BUYER.
      h. Identify all piping thus treated with special metal tag.

   3. Piping not cycle or lube oil related shall be cleaned as follows.
      a. Remove loose scale, sand, weld spatter, cutting chips, and other foreign material by means of mechanically driven cleaning tools and/or wire brush.
      b. Blow out piping with compressed air. Additional surface preparation may be required if coated.
      c. Follow coating manufacturer’s recommendations.

G. Interior coatings:
   1. Water and steam piping: Interior surfaces and flange faces shall be completely coated with suitable rust preventive soluble in water. Use Dubois 200, Ardrox 228-M, or equal.
2. Oil piping: Interior surfaces and flange faces shall be completely coated with suitable rust preventative soluble in oil. Use Houghton Rust-Veto 344, Rustoleum R-9, or equal.

H. Exterior surface coatings:
1. Refer to Section 09 92 00 – Industrial Painting and Coating for requirements.
2. Piping to be insulated: Prime exterior surfaces in accordance with Coating System “A”.
3. Uninsulated piping operating above manufacturer's recommended temperature for low temperature primer: Prime exterior surfaces in accordance with Coating System “C” or “D” as appropriate for the service.
4. Piping internals, flange faces, threaded surfaces, and piping within 3” of field welds shall not be painted. Coat field weld area with welding consumable such as Deoxaluminate, Bloxide, or equal, to prevent surface corrosion.
5. Where interior surface is shot-blast cleaned, exterior blasting media shall use same media as internal to prevent contamination.

I. Use painting materials of metallic pigment type free of asphalt or asphaltum base.

PART 3 EXECUTION

3.01 IDENTIFICATION OF MATERIALS

A. Identify all components with identification numbers that are in accordance with Buyers plant numbering system. Coordinate individual tag numbers with the Buyer to avoid duplication of tag numbers.

B. Tag each valve or other specialty item with identification number shown with permanent stainless steel tags; tag shall bear equipment name as well as numerical reference where applicable.

C. Valves and piping specialty items shall bear manufacturer's permanently affixed stamp or tag indicating manufacturer, catalog number, pressure and temperature rating, and construction materials.

D. Prior to shipping any random lengths of steel pipe to job site, mark pipe, other than ASTM A53 welded steel pipe, with an identifying code consisting of longitudinal color stripe painted entire length of each piece of pipe to identify ASTM designation of material.

E. Provide Buyer with identification code.

F. Paint identifying numbers on each end and each side on sections of prefabricated piping corresponding to identifying numbers shown on Sellers fabrication drawings. If piping is fabricated in several spool pieces, a letter suffix shall be assigned each spool piece starting with “A” at upstream end of pipe.

G. Stamp or permanently mark alloy steel bolting material to avoid mixing with carbon steel material.

H. Buyer reserves right to reject piping items which cannot be readily identified as to construction materials.

3.02 WELDING

A. Refer to Section 01 43 30.

3.03 PIPE SLOPE AND GRADING

A. Provide as necessary to permit draining of systems.

B. Indicate required slope on drawings where applicable.

3.04 SAFETY VALVE VENTS

A. Safety valve vents shall be of the open stack design unless otherwise approved by the owner.
B. Provide drip pan elbows and vent stacks for all safety valves provided by Seller.

C. Vent stacks penetrating the roof shall extend a minimum of 10 feet above the roof line.

D. Perform calculations to determine the correct safety valve vent stack size. The vent stack shall be two sizes bigger than the safety valve outlet diameter, at a minimum.

E. Locate vent stack relative to outlet of drip pan elbow to accommodate thermal movements of the elbow outlet.

F. Provide drain lines from drip pan, elbow, and valve body for each safety valve. Drain lines shall be run to nearest bellup or floor drain.

### 3.05 PIPE SLEEVES

A. Sleeves shall be furnished for piping provided under this Contract. Sleeves shall extend 4" above floors include 1/4" thick diaphragm plate 6" larger than sleeve OD for anchoring in concrete.

B. Sleeve material: Standard weight carbon steel pipe.

C. Sleeves through walls and roofs shall include penetration of wall and roof materials.

D. Select sleeve sizes to allow concentric radial clearance between sleeve and outer covering of piping including insulation, and pipe circuit as follows:
   1. Piping with high thermal expansion may require special size sleeves. Determine size of sleeves based on pipe movements.
   2. Nominal pipe diameter 2-1/2" or larger: 3".
   3. Nominal pipe diameter 2" or smaller: 2".
   4. Select sleeve diameter to accommodate seals where applicable.

### 3.06 NONDESTRUCTIVE EXAMINATIONS

A. Piping and welded joints shall be examined and tested in accordance with applicable ASME codes.

B. Examination and testing of pipe, fittings, welds, and piping components:
   1. Test materials in accordance with requirements of applicable codes and standards as specified.
   2. Pressure piping shall be examined and tested in accordance with applicable ASME codes.
   3. Acceptance criteria shall be in accordance with applicable ASME codes.
   4. Seller shall be responsible for required examinations and tests of shop welded piping.

C. Radiography:
   1. Permanent identification of each film shall include:
      a. Date.
      b. Location.
      c. Specification.
      d. Component.
      e. Manufacturer's identification.
      f. Letter "R" used to designate reshot of repair.
   2. Submit radiographic film and required reports to independent testing laboratory for review and comment. After submittal, Seller may proceed with work at its own risk.
   3. Seller shall make required provisions for radiographs. In locations where radioactive source cannot be placed inside pipe in any other way, Seller may be required to install a thread-o-let radiograph access port. After radiograph is completed and results approved, Seller shall screw and seal-weld recessed plug into access hole.

D. Buyer, at its option, may perform examinations, inspections, and tests of piping and welded joints to verify compliance with applicable ASME codes including, but not limited to, visual observation, ultrasonic, liquid-
penetrant, and magnetic particle methods. These tests may be conducted in the fabrication facility or in the field after delivery, at the Buyers discretion.

END OF SECTION

1) J. Solan
2) J. Ayers
PART 1 GENERAL

1.01 SECTION INCLUDES

A. Furnish valves for the following applications:
   1. All valves within the jurisdiction of the ASME B31.1.
   2. Valves identified in Section 01 11 00 – Summary of Work
   3. Vent and drain valves for equipment furnished under this contract.
   4. Drain and vent valves required to drain low points and vent high points in piping.
   5. Connections to metering instruments and controls including pressure gages, transmitters, controllers, traps, and appurtenances required for proper functioning of instruments and controls.
   6. Temporary valves and accessories required for placing equipment into initial service.
   7. Valves which are inherent to operation or protection of equipment furnished by Seller.
   8. Piping 2" and smaller required for proper operation of piping system and equipment, including drain and vent valves required to drain low points and vent high points in piping. No additional compensation will be allowed for drain or vent valves and piping 2" and smaller.

1.02 SUBMITTALS

A. Submit Valve List identifying service, application, size, pressure/temperature rating, manufacturer, type, and model number for each valve.

B. Submit outline drawing / vendor cut sheet of each type of valve identifying, size, type, manufacturer, figure number, pressure/temperature rating, and materials of construction.

1.03 QUALITY ASSURANCE

A. Each valve shall be equipped with manufacturer's permanent engraved nameplate identifying valve manufacturer, figure number, and pressure class.

PART 2 PRODUCTS

2.01 VALVES - GENERAL

A. Size, type, materials of construction, and pressure class of valves shall be selected by Seller to accommodate service, flow rate, and pressure/temperature conditions of application.

B. Weld end connections shall be prepared in accordance with ASME 16.5 as follows: For nominal pipe wall thickness of 0.375" and less, conform to ASME B16.25, Figure 2, Detail (1). Counterbore tolerance shall be +/- 0.031". For nominal pipe wall thickness greater than 0.375", conform to ASME B16.25, Figure 5 or 6.

C. Control valves: Refer to Section 40 91 00 – Primary Process Measuring Devices.

D. Valves shall be of same manufacturer for each class of piping and insofar as possible for entire Project. Approved manufacturers are listed in Section 01 63 00 – Approved Subcontractors and Suppliers list.

E. Valve ends:
   1. General service:
      a. Cast iron and cast steel valves: Sizes 2-1/2" and larger, flanged; size 2" and smaller, screwed.
      b. Bronze valves: Screwed or solder joint.
      c. Steel valves: Welded. Weld end connection of butt-welding valves shall be prepared in accordance with Mechanical Standards.
   2. Steam and condensate piping:
      a. Size 2-1/2" and larger: Butt weld valves.
      b. Size 2" and smaller: socket-weld steel.
3. Compressed air and instrument air: Screwed or solder joint.
4. Bypass: In accordance with applicable Mechanical Standards

F. Provide special tools required for repacking and disassembling valves provided.

G. Comply with ANSI B31.1 and ASME Boiler and Pressure Vessel Code.

H. Valves installed in combustible or flammable liquid or gas service shall be UL/FM approved.

I. Gate valve discs: Flexible disc or as required by intended service.

J. Valve seats:
   1. Globe valves: Renewable except as otherwise approved by the Buyer.
   2. Gate valves: Renewable seats all valves 2-1/2" and larger.

K. Provide double seated valves on hot services with internal bonnet pressure relief provisions in accordance with ANSI B16.34 to prevent excessive internal pressures due to fluid thermal expansion.

L. Cast steel gate, globe, and check valves 2-1/2" and larger shall have seal welded seat rings.

M. Valves ANSI Class 600 and higher shall have integral back seat.

2.02 VALVE OPERATORS AND VALVE ACCESSORIES

A. Provide standard wheel operators for globe and gate valves, unless otherwise specified.

B. Provide mechanical gear operators for 8" and larger 300 lb and above valves in steam and condensate service.

C. Plug valves: Standard lever operators.

D. Ball valves: Standard lever operators.

E. Butterfly valves:
   1. 6" and smaller: Lever operated with lever locking device.
   2. 8" and larger: Hand wheel and gear drive.

F. Handwheels:
   1. Maximum force applied to rim of handwheel, to seat or unseat valve against full differential operating pressure, shall be limited to 75 lb.
   2. Provide heavy steel impact handwheels or enclosed bevel gear with hammer blow action where necessary to conform to 75 lb maximum applied force limitation.
   3. Other valve handwheels shall be direct connected and of sufficient size to allow seating and unseating of valve against full differential operating pressure without the use of auxiliary tools.
   4. Provide operating nut or lug for air wrench valve operation on valves requiring hammer blow action.
   5. Provide mechanical gear operators with adjustable limit stops.

G. Provide locking devices where shown on Drawings. Buyer will provide locks.

H. Provide chain wheel operators for manual valves with handwheel operators in horizontal plane located 6'-6" above floor, unless otherwise noted. Provide sufficient chain to bring operation down to 6'-6" above floor.

2.03 VENT AND DRAIN VALVES

A. Provide vents at high points and drains at low points of piping. Provide as shown and as required for piping furnished including nondetailed piping.
B. Drain and vent valves, except where noted otherwise:
   1. Piping 2" and smaller: 1/2" globe.
   2. Piping 2-1/2" through 5": 3/4" globe.
   4. Provide double block valves where required by code.

2.04 BALL VALVES

A. General service:
   1. Use where indicated, or may be used in place of gate or globe valves 2" and smaller indicated on water services with design pressure of 150 psi or less and design temperatures of 220°F or less.
   2. Body: Bronze, brass, or cast iron threaded, 2-piece construction.
   3. Ball and stem: Bronze, brass, or stainless steel.
   5. Seat: Manufacturer's standard at working conditions specified.

B. Fuel oil and natural gas service:
   1. 2" and smaller:
      a. Valve ends: Socket welded.
      b. Body: Carbon steel, ASTM A105, with emergency body seal.
      c. Ball: Stainless steel.
      d. Valve style: 3-piece.
      e. Stem: Stainless steel.
      f. Seat: Nylon with seat ring and emergency gasket.
      g. Body seal: TFE.
      h. Stem seal: TFE with emergency backup seal.
      i. Seat ring: Carbon steel.
      j. Design: Fire tested in accordance with API-607.
      k. Manufacturer: Neles-Jamesbury "Fire-Tite,", PBV, or equal.
   2. 2-1/2" and larger:
      a. ANSI pressure class: 150 lb.
      b. Valve ends: Flanged.
      d. Trim: Stainless steel.
      e. Seat and seal material: TFE.
      f. Design: Fire-tested in accordance with API 607.
      g. Manufacturer: Neles-Jamesbury Corp. Series 5000 "Fire-Tite,", PBV, or equal.

2.05 BUTTERFLY VALVES

A. Cold Water Service
   1. Body: Ductile iron for mounting between flanges. Provide threaded lugs making valve suitable for deadend service with 1 flange removed.
   2. Disc: Stainless steel.
   3. Stem: Type 316 stainless steel.
   5. Manufacturer: Reference Section 01 63 00 – Approved Subcontractors and Suppliers List

B. Steam Service
   1. High performance, triple-offset butterfly valves may be used, upon Buyer approval, in lieu of gate valves in locations where the Seller feels the use of a butterfly valve may be advantageous.
   2. Submit location(s) and proposed valve data sheets to Buyer for approval prior to utilizing butterfly valves in steam services.

2.06 CHECK VALVES

A. Hinged split disc type: Spring closing, Mission "Duo-Chek II" or Centerline.
B. Swing disc type, with hinged disc: Reference Section 01 63 00 – Approved Subcontractors and Suppliers List

2.07 NEEDLE VALVES

A. Low-pressure applications (125 psig and less):
   1. Body: Bronze, with screwed bonnet and integral V-seat.
   2. Valve ends: Screwed.
   3. Needle valve stem and disc.
   4. Regulating wheel and indicator.
   5. Service: Cooling water.

B. High-pressure applications (150 psig and greater):
   2. Valve ends: Screwed.
   4. Service: Steam.

C. Manufacturer: Lunkenheimer.

2.08 AUTOMATIC NONRETURN VALVE

A. Type: Automatic, nonreturn, stop check.

B. Body: Cast steel, bolted bonnet.

C. Seat, disk, and backseat: Stellite.

D. Valve ends: Butt weld.

E. Rating: ANSI Class: As required.

F. Manufacturer: Edward Valves or equal with equalizer and impactor handwheel.

2.09 SAFETY VALVES

A. Boiler and superheater: Sufficient number and size to relieve maximum steaming capacity of boiler.

B. In addition to ASME Code requirements, provide a Power Operated Relief Valve (P.O.R.V.) with a manually operated isolation valve for each P.O.R.V. in each superheater Outlet Lead. Size P.O.R.V. for 20% of superheater design flow, at a minimum.

C. Mount superheater safety valves on piping provided under this contract.

D. Manufacturer: Consolidated, Crosby, or Farris.

2.10 FEEDWATER STOP VALVE

A. Type: Globe.

B. Body: Cast steel, bolted bonnet.

C. Seat, disk, and backseat: Stellite.

D. Valve ends: Butt weld.

E. Rating: ANSI Class: As required.
F. Manufacturer: Edward Valves or equal with impactor handwheel.

2.11 FEEDWATER CHECK VALVE

A. Type: Swing check.
B. Body: Cast steel, bolted cover.
C. Seat: Stellite.
D. Valve ends: Butt weld.
E. Rating: ANSI Class: As required.
F. Manufacturer: Edward Valves or equal.
G. Oriented in a horizontal pipe run.

2.12 CONTINUOUS BLOWDOWN VALVE

A. "Orifice-Meter Flow Control Unit" by The Madden Corporation.

2.13 BLOW-OFF VALVES

A. Type: Tandem blow-off valves, in sufficient number to permit blowing down boiler and draining water wall headers and economizer.
B. Seat: Stellite, integral.
C. Disk: Stellite.
D. Valve ends: Welded.
E. Rating: ANSI Class: As required.
F. Manufacturer: Yarway "Unit-Tandem", Edward Valves, or equal.
G. Provide locking devices for blow-off valves.

2.14 MISCELLANEOUS PRESSURE PART VALVES

A. Valves 2" and smaller:
   1. Type: Globe.
   5. Rating: ANSI Class: As required.
B. Valves 2-1/2" and larger:
   1. Body: Cast steel, bolted bonnet.
   3. Valve ends: Butt weld.
   4. Rating: ANSI Class: As required.
   5. Manufacturer: Edward Valves, Velan, Crane, or equal.

2.15 GAGE COCK
A. Low pressure applications (125 psig and less):
   1. Bronze body with screwed bonnet and integral V-seat.
   2. Needle valve stem and disc.
   3. Regulating wheel and indicator.
   4. Screwed end connections.
   5. Service: Cooling water and treated water, feedwater blowdown, condensate samples, and gage isolation.

B. High pressure applications (150 psig and greater):
   1. Carbon steel bar stock body with integral seats.
   2. Stainless steel needle valve stem and disc.
   3. Screwed end connections.
   4. Service: Steam and blowdown sample.

C. Manufacturer: Lunkenheimer.

2.16 VALVES - MISCELLANEOUS SERVICES

A. Valves installed in piping systems for auxiliary services shall conform to requirements of Mechanical Standards.

2.17 VALVE OPERATORS

A. Motor operators:
   1. Motor:
      a. 460-volt, 3-phase or 120-volt, single-phase, 60 Hz.
      c. Class B insulation, 40ºC ambient condition.
      d. Reversible squirrel cage induction-type, suitable for across-the-line starting.
      e. Size as required for valve operating against full design pressure.
   2. Gear reducer: Totally enclosed, oil bath-lubricated.
   3. Limit switches:
      a. As required to stop motor at ends of travel and to operate "open" and "closed" position indicating lights.
      b. Provide a minimum of 2 spares for interlock and/or alarm.
      c. Contact terminals shall be identified and arranged for external connections by others.
      d. Switches suitable for 6-amperes at 120 volts ac control voltage.
   4. Torque limit switches to prevent damage due to obstructions. Provide switches that will reset only after torque has been removed. Suitable for 6-amperes at 120 volts, ac control voltage.
   5. Operators for outdoor service shall be suitably weatherproofed and supplied with limit switch compartment heaters.
   6. Switches shall be set at factory.
   7. Provide clutch and handwheel for manual operation.
   8. Motor starter: As required.

B. Valve floor stands:
   1. Type: Steel with bottom flange faced and drilled for bolting to floor.
   2. Floor stands for use with valves having integral bypasses shall be provided with side arms and separate handwheels for operating bypass valves.
   3. Provide pipe extensions, extension stems, universal joints, stem guide bearings, and other accessories required to locate floor stands in convenient location without interference with other equipment, piping, or building parts.
   4. Provide supports as necessary to support floor stands mounted on grating platforms.
   5. Where floor stand operates valve through reducing gears, floor stand indicator shall be coordinated with valve position for full valve travel.
   6. Furnish tubing and grease fittings to allow greasing of gear operators from floor stand base for those valves supplied with floor stands.
C. Solenoids:
   1. 120 volts, single-phase, 60 Hz coil(s) rated for continuous duty, Class H insulation suitable for operating temperatures of 180ºF; equip with 18" long leads.
   2. Enclosure: Explosionproof and watertight.
   3. Manufacturer: ASCO.

2.18 VALVE IDENTIFICATION

A. Tag valves with stainless steel tags.

B. Size: Not less than 1" in diameter with black etched numbers 1/2" high.

C. Provide Valve List for each piping system. Data should be provided in electronic document format (PDF) and in a format that can be easily imported into a plant information database (Excel, Access database, or similar). List following:
   1. Each valve number.
   2. Valve description.
   3. Valve type (ball, check, butterfly, etc.)
   4. Valve size
   5. Minimum ANSI class
   6. Body material
   7. End prep (for each end if different)
   8. Valve manufacturer.
   9. Pipe line identification number for pipe in which valve is installed
   10. Pipe design pressure
   11. Pipe design temperature
   12. Fluid
   13. Manufacturer's figure or model number.

D. Seller shall coordinate valve numbering system with Buyers requirements.

PART 3 EXECUTION

3.01 VALVE INSTALLATION DESIGN

A. Locate and design valves with operating stem in upright position, insofar as practicable.

B. Locate for access from adjacent floor or platform. Use of chain operators or ladders is not acceptable without prior owner approval or unless specified elsewhere.

C. First valve on elevated pressure part drains, blowoffs, and blowdowns shall be designed to be near header or device. Second valve shall be located at first platform elevation below feeder floor. Drain and blowdown valves shall be clustered in one common area accessible at first platform elevation below feeder floor.

END OF SECTION
PART 1  GENERAL

1.01  SECTION INCLUDES

A. Computer-aided stress analysis of piping systems.

B. Design of pipe support systems, equipment support systems and supplementary support steel.

C. Fabrication:
   1. Pipe and equipment supports.
   2. Supplementary support steel.

1.02  DEFINITIONS

A. Pipe or equipment support system: Collection of supports used to restrain movement and provide support to an entire piping system or equipment.

B. Pipe or equipment support system design includes, but not limited to the following:
   1. Determination of support locations, types of support, support reactions and displacements of pipe and/or equipment at support locations.
   2. Verification that pipe support system meets requirements of paragraph 2.01 “Pipe Support System Design.”

C. Pipe or equipment supports: Hangers, guides, rollers, slide supports, springs, anchors, struts, snubbers, or any other devices used to restrain movement or provide support to pipe or equipment.

D. Design categories of pipe supports are defined as follows. Following definitions are in addition to definitions of information and materials defined by MSS SP-58 and MSS SP-127.
   1. Completely engineered supports:
      a. Supports where the specific component size is established by the individual support design.
      b. Details of each support shall be prepared containing all information specified in MSS SP-58 Annex B, "Pipe Hanger Assembly Drawings.”
   2. Semi-engineered supports:
      a. Supports that are designed from similar support configurations from which a specific component size can be established and applied to a group of (or like) supports.
      b. Loading and movement design criteria shall encompass most stringent conditions of group. Bill of Material for each support need not be established.
      c. Supports may be field fabricated from stock materials.
   3. Common supports: Supports which require no engineering and may be field-fabricated from stock materials.

E. Supplementary support steel: All steel necessary to support pipe and equipment in addition to existing structure or new structure installed for this project, irrespective of contract. Existing or new structure is typically structural steel, reinforced concrete or concrete masonry units. Hereinafter, existing or new steel is referred to as “existing steel”.
   1. Supplementary support steel includes, but is not limited to, the following:
      a. Steel beams, posts, hangers, diagonal braces, plates, cut shapes, epoxy grouted anchor rods, studs and other similar types of construction, as required for support of pipe and equipment.
      b. Localized stiffening of existing steel or supplementary support steel at pipe and equipment support connections.
   2. Supplementary support steel shall include steel extending down to foundation floor slab where supporting pipe or equipment from above is prohibited by Engineer.
   3. Supplementary support steel does not include standard pipe support hardware.

1.03  PIPE AND PIPE SUPPORT DESIGN RESPONSIBILITIES

A. Seller is responsible for ensuring the proper support of all piping supplied by the Seller under this contract. Buyer will assume the responsibility for proper support of piping systems outside of the Sellers termination points.
B. Buyer and Seller shall coordinate pipe stress calculations and support designs for piping systems that are partially supplied by each party.

C. Design of supplementary steel is the responsibility of the Seller for all Seller provided supports.

<table>
<thead>
<tr>
<th>Sellers Design Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design Temperature</strong></td>
</tr>
<tr>
<td><strong>Pipe Size</strong></td>
</tr>
<tr>
<td><strong>Computer-aided Stress Analysis</strong></td>
</tr>
<tr>
<td><strong>Minimum Pipe Support Design Category</strong></td>
</tr>
</tbody>
</table>

1.04 ACTION SUBMITTALS

A. Shop Drawings:
1. Piping plans and elevations or isometric drawings showing pipe support systems designed by Seller. Drawings shall show pipe support (by use of symbol), support identification number and locations. Submittal required for all semi-engineered or completely-engineered pipe supports.
2. Details for semi-engineered pipe supports. Support details shall show localized stiffening of support steel at support connection, where applicable.
3. Details for each completely engineered pipe support shall contain necessary information specified in MSS SP-58 Annex B, "Pipe Hanger Assembly Drawings." Drawings shall show supplementary support steel, localized stiffening of existing support steel and supplementary support steel at support connection, all where applicable. Final revision of pipe hanger assembly drawings shall be submitted in both electronic CAD format and electronic PDF copy.
4. Complete framing plans for each floor showing existing steel, supplementary support steel, locations where pipe supports connect to supplementary support steel or existing steel, pipe support mark numbers and actual support loads. Include all completely engineered supports.
5. Supports for equipment noted in paragraph 1.05 "Quality Assurance".
6. Engineering drawings showing modifications of existing building steel.

B. Quality assurance data:
1. Published pre-engineered standard pipe support components utilized on project. Include allowable loads.
2. Pre-engineered standard support certifications as defined in article "Pipe Support Design."
3. Hanger record sheets in accordance with MSS SP-58 (Figure 3).
4. Revisions to "Pipe Hanger Assembly Drawings" shall have all changes "clouded" for identification.
5. Equipment supports, associated supplementary support steel (if required) and support loads.

1.05 QUALITY ASSURANCE

A. Pipe hangers and supports, fabrication, and installation practices shall be in accordance with MSS SP-58.

B. Computer-aided stress analysis shall be completed and made available for Buyers review at the Sellers facilities. The calculations shall include:
1. Drawings showing computer model with node numbers, support identification number, and support type.
2. Inputs.
3. Code compliance reports.
4. Allowable nozzle load met.
5. Cold and hot displacements.
6. Anchor and restraint forces and moments.
C. Computations for design of supplementary support steel and stiffening of existing building steel for support loads shall be completed and made available for Buyers review at the Sellers facilities.

D. Following shall be performed by or under direction of professional engineer licensed in State of Alaska and retained by Seller for piping systems outside of the BPVC piping boundaries as required by law. Submittals shall be signed and sealed by such engineer:
   1. Pipe stress analysis.
   2. Semi-engineered pipe support design.
   3. Completely engineered pipe support design.
   4. Design of major equipment supports.
   5. Design of attachment of support to existing structure or supplementary support steel where attachment details and allowable loads are not included in published pre-engineered standard support data by manufacturer (e.g., weld requirements, bolts, anchor rods, expansion anchors, etc.)
   6. Design of supplementary support steel designed by Seller.
   7. Design of localized stiffening of existing steel and supplementary support steel.

E. Seller’s professional engineer’s seal is not required for design of support where published pre-engineered standard supports with published ratings, loads, and movements are used. Pre-engineered standard supports (including all components) shall be certified by Seller as acceptable for intended use on this project. See article "Pipe Support Design" for certification requirements.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Anvil International.

B. Bergen-Power (Patterson).

C. Binder.

D. Lisega.

E. Pipe Hanger Specialists (PHS).

F. Piping Technology & Products (PT&P).

G. Rilco.

2.02 PIPE SUPPORT SYSTEM DESIGN

A. Design all pipe support systems as noted in paragraph 1.03 “Pipe and Pipe Support Design Responsibilities.”

B. Pipe support system shall result in pipe stress conforming to requirements of ASME B31.1 or ASME BPVC as applicable.

C. Where possible, pipe support locations shall be located to prevent individual structural members from being excessively loaded.

D. Pipe support selection and application: Using pipe support spacing shown in MSS SP-58 Table 4 with following additional requirements:
   1. Additional supports are required at concentrated loads between supports such as flanges, valves, specialties, etc.
   2. Support spacing values in MSS SP-58 Table 4 shall be reduced by 25% when pipe changes horizontal direction between supports.

E. Incorporate seismic limit ties, guides, and stops to resist lateral loads.
F. Locate supports for pipe connected to equipment to limit equipment reactions to allowable reactions specified by equipment manufacturer.

G. Supports for pipe terminating at existing pipe connections shall accommodate thermal movement and loads imposed by existing pipe.

2.03 PIPE SUPPORT DESIGN

A. Design all pipe supports as noted in paragraph “Pipe and Pipe Support Design Responsibilities”.

B. Conceptual support details on Drawings do not represent a design and are intended only to convey MSS type of support assumed by Engineer. Modify support conceptual details as necessary to limit support and pipe stresses to allowable stresses.

C. Conform to MSS SP-58.

D. Design supports such that total of pipe global and local stresses shall not exceed allowable stresses specified in ASME B31.1.

E. Design of all welded attachments to pipe per ASME B31.1 or BPVC. Design of welded attachment shall not exceed allowable stresses specified in ASME B31.1 or BPVC. Welded attachment shall be of similar material as pipe.

F. Seller’s design shall accommodate hydrostatic testing of pipe when applicable.

G. Where pre-engineered standard supports are used, Seller’s design requirements shall include:
   1. Obtaining manufacturer's certification that manufacturer's support design conforms to above referenced standards.
   2. Verification that loads for particular support application(s) do not exceed manufacturer's specified allowable support loads.
   3. Where applicable, verification that pipe movement at support does not exceed manufacturer's allowable.

H. Include type, size and length of welds and type, size, and number of bolts required for attachment of pipe support to support structure.

I. Ensure that support designs do not cause any field interference. All interferences must be resolved prior to the pipe support drawing being issued.

J. Supports inducing torsion in existing structural members are not permitted except where shown on Drawings.

K. Where supports connect to structural steel members and cause localized bending of member flanges or webs, stiffen member as necessary to limit localized bending stress to less than 3 ksi. Design of stiffeners and welds shall be by Seller.

L. Support location shall be adjusted to offset for 1/2 hot displacement. Support shall hang within 4° of vertical under all conditions.

2.04 EQUIPMENT SUPPORT DESIGN

A. Design equipment support system, supports, and associated supplementary support steel.

B. Base equipment support design upon following parameters:
   1. Support loads.
   2. Equipment movements at supports.
   3. Equipment manufacturer's requirements.
C. Fabricate equipment supports not provided by equipment manufacturer from structural grade steel meeting requirements of Section 05 10 00.

D. Where equipment supports are designed by entity other than equipment supplier, obtain equipment supplier's approval of support system.

E. Support design should account for possible occasional loading observed during operation.

2.05 COMPUTER-AIDED PIPE STRESS ANALYSIS

A. Perform computer-aided pipe stress analysis for piping systems indicated in paragraph 1.03, “Design Responsibilities” in accordance with ASME B31.1 and BPVC.

B. Analysis shall include effects of occasional loads from seismic events in accordance with International Building Code.

C. Provide bends, offsets, or loops in piping as required to permit pipe expansion due to temperature change and equipment movement. Perform additional analyses until all overstress conditions are resolved and nozzle loading compliance is achieved.

D. Use of “cut shorts,” “cold pulling,” or “cold spring” shall be used only after all other options have been exhausted and shall require written approval of Buyer prior to use.

2.06 PIPE AND EQUIPMENT SUPPORTS

A. Materials and manufacture: MSS SP-58, ASME BPVC, and ASME B31.1.

B. Supports and accessory items shall have manufacturer's standard shop-applied primer and standard finish coat, unless specified otherwise.

C. Provide insulation protection shields of sufficient size and gage to prevent crushing of insulation at supports.

D. Hot duct, flue, and breeching supports:
   1. Slide bearing plates:
      a. Size to accommodate loads and thermal movements of duct, flue, or breeching. Conform to requirements of manufacturer.
      b. Type: Bronze alloy or teflon suitable for bearing pressures, movements, and temperatures.
      c. Maximum static coefficient of friction: 0.1.
      d. Ensure that design is acceptable with and without the presence of friction.
      e. Extend upper sliding surface to maintain 1” (25 mm) minimum beyond edge of lower sliding surface through full range of movements.
   2. Springs:
      a. Constant-support type to maintain support of duct, flue, or breeching through full ranges of vertical and horizontal movements.
      b. Size to take dead weight of duct, flue, or breeching including insulation, lagging, appurtenances, and one half of expansion joints.
      c. Travel: Establish using design temperature determined by Sellers duct design.
      d. Construction: Helical spring(s) mounted in carbon (structural) steel housing and having linkage arranged to permit maintenance of constant load throughout movement range. Provide with movement indicator dial to facilitate initial set and adjustment.
   3. Anchors and seismic restraints:
      a. Structural plate (ASTM A36) anchor supports where indicated and required.
      b. Seismic restraints shall limit movement of individual duct, flue, or breeching sections to control movements in expansion joints to acceptable limits without damage to expansion joint or attached and adjacent equipment and construction.
      c. Locate to minimize effects of differential movement and torsion on supports.
   4. Supports for duct, flue, or breeching at universal-type expansion joint arrangements shall be reviewed and approved by expansion joint manufacturer.
   5. Supports for duct, flue, or breeching shall include:
SUPPORTS AND ANCHORS FOR PROCESS PIPING AND EQUIPMENT

SECTION 3418.40 05 29 - Page 6

2.07 SUPPLEMENTARY SUPPORT STEEL

A. Material: ASTM A36, or A572 Grade 50.

B. Design of supplementary support steel shall be in accordance with 2005 AISC “Specification for Structural Steel Buildings.”

C. Supplementary support steel that induces torsion in support member is not permitted, except where shown on Drawings.

D. Design supplementary support steel as necessary to prevent excessive loads in existing steel members due to pipe support loads. Supplementary support steel is subject to review by Buyer.

E. Furnish supplementary support steel with loose clip angles for attachment to structure. Bolt connections to existing columns or other existing steel insofar as practicable. Where connections are common connections with existing steel, new bolts, washers, and nuts shall be supplied under this contract.

F. Supplementary support steel shall conform to requirements of Section 05 10 00 and 05 50 00.

G. Welding to beam flanges permitted only where welds are parallel to and directly opposite webs. Submit other welding details to Buyer for review.

H. Welding: AWS D1.1. Refer to Section 01 43 30.

PART 3 EXECUTION

3.01 PIPING SUPPORTS

A. Fabrication and installation: MSS SP-58.

3.02 EQUIPMENT SUPPORTS

A. Arrange supports to provide clear access to equipment and to maintain clear aisle and access ways. Arrangement of equipment supports shall be subject to review by Buyer.
B. Provide necessary anchor bolts, expansion anchors and anchor rods for mounting equipment to concrete. See Section 05 50 00 for requirements.

END OF SECTION
PART 1  GENERAL

1.01  SECTION INCLUDES

A. Instruments and control equipment:
   1. Pressure sensing devices.
   2. Flow sensing devices.
   3. Level sensing devices.
   4. Temperature sensing devices.
   5. Analytical devices.
   6. Control valves.
   7. Safety relief valves.

1.02  RELATED REQUIREMENTS

A. Section 40 95 13 – Process Control Panels and Hardware.
B. Section 40 96 00 – Process Control Software.

1.03  PRODUCTS SUPPLIED BUT NOT INSTALLED

A. Seller shall supply all instruments and control devices necessary for proper operation and monitoring of their equipment.

1.04  WORK BY OTHERS

A. Field installation of Seller supplied instruments and control equipment including mounting, process connections and wiring.
B. Electrical power supplies as required for equipment operation
C. Clean, dry instrument air supply as required for equipment operation

1.05  INFORMATIONAL SUBMITTALS

A. Submit with Bid: Preliminary instrument listing including instrument tag number, manufacturer, and model number.
B. Submitted information relating to instrumentation and control devices shall be referenced by instrument tag number.
C. Product Data: Spare parts lists including maintenance, special tools, test equipment, and name with address of manufacturer’s local supplier for spare parts.

1.06  ACTION SUBMITTALS

A. Product Data:
   1. Manufacturer’s data or specification sheets for instrumentation and control devices showing design parameters, equipment catalog designations, calibration range, and clearly identifying options provided.
   2. Instrument listing: Listing shall be oriented by instrument tag number and include manufacturer, model number, calibrated range, and setpoint values.
   3. Certified calculation sheets:
      a. Flow meter sizing.
      b. Thermowell stress analysis.

Rev. 0
c. Control valve sizing and aerodynamic noise predictions.

d. Pressure relieving device sizing.

B. Shop Drawings:
   1. Certified outline drawings.
   2. Installation drawings including mounting and grounding requirements.
   3. Wiring interconnection drawings for equipment and accessories provided. Wiring interconnection drawings shall define terminal numbers and functions for interface with other instruments and equipment.
   4. Instrument Location Drawings showing process tap locations and recommended accessible mounting locations including elevations.
   5. Recommended Instrument Installation Details showing required connections to process lines or vessels.

1.07 CLOSEOUT SUBMITTALS

A. Operation and maintenance manuals:
   1. Complete instruction manuals and parts lists covering installation, operation, wiring interconnections, and maintenance of equipment.
   2. Include component manuals as a part of the complete Operation and Maintenance Manual

B. Record Documents:
   1. Certified “As-built” instrument drawings as defined above showing any changes that occurred during the design process.
   2. Instrumentation calibration reports

1.08 MAINTENANCE MATERIALS

A. Provide 1-year supply of spare parts as recommended by equipment manufacturer as part of initial installation.

1.09 QUALITY ASSURANCE

A. Provide Instruments and control valves manufactured by Fisher-Rosemount when possible. When a Fisher-Rosemount product is not available, submit proposed instrument to Buyer for approval prior to the purchase of the instrument.

B. Provide instruments from same manufacturer and of same model series when multiple units of same item are required.

C. Instruments, control devices, and accessories shall be free of mercury and asbestos.

D. Use plant instrument air source pressure or furnish pressure regulator with filter and output gage.

E. Furnish insect-proof screens on vents.

F. Furnish new and unused instruments and control devices.

G. Provide linkages, mounting accessories, etc. necessary to place device into service.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Prior to shipment, provide to Buyer control panels and enclosures storage and handling requirements to ensure availability of proper storage space and procedures are followed.

B. Ship control panels as recommended by control panel/enclosure manufacturer.
C. Packaging of all equipment shall be suitable for transport via an oceangoing vessel.

D. Provide removable eye bolt lifting lugs for large panels and suitable skids for safe handling.

E. Goods shall be suitably packaged, marked, and shipped in a manner and sufficient documentation that will allow identification of contents without un-packaging

PART 2 PRODUCTS

2.01 DESIGN REQUIREMENTS

A. Instrumentation, tubing, fittings, and valves shall comply with Power Piping Code ASME B31.1 and BPVC.

B. Where required for performance testing, instruments shall meet the requirements of the applicable ASME performance test code.

C. Instruments shall be suitable for the area classification in which they will be located.

D. Electric power sources are 120 VAC 60 Hz and 24 VDC loop power.

E. Instrument air pressure is nominal 80–100 PSIG.

F. Transmitters to be smart type with 4-20 mA, HART compatible outputs and shall be factory calibrated with calibration certificate.

G. Pressure transmitters to be furnished with flange type 2-valve SS manifolds and differential pressure transmitters with 3-valve SS manifolds.

H. The functionality of switches shall be replaced through the use of transmitting sensors and control logic in the plant DCS to the greatest extent possible. Switches may be used in circumstances where there is no other viable option.

I. Flow meters:
   5. Submit certified calculation sheets verifying meter selection for operating conditions at minimum and maximum flow rate.

J. Temperature measurement:
   1. RTDs shall be utilized for all applications where either RTDs or thermocouples are equally appropriate. All other applications shall utilize the most appropriate means of temperature measurement, as determined by the Seller.
   2. RTDs:
      a. RTD: 3 or 4 wire, 100 Ohm platinum, conforming to IEC 751 Class B.
      b. Cover style: Standard.
      c. Cover material: Standard.
      d. Sensor style: Spring-loaded.
      e. Element: Dual.
      f. Element length: Sized to suit thermowell.
g. Lead configuration: See Section 40 91 00-2.09.

h. Sheath diameter: 1/4” (6 mm).

i. Sheath material: Rated for high temperatures up to 1,070°F (577°C) or above.

j. Extension type: 4" (100 mm) nipple-union-nipple.

k. Extension material: Carbon steel.

l. Connection: 1/2” (13 mm) NPT.

m. Electrical connection: 3/4” NPT.

3. Thermocouples:
   a. Thermocouple: Type E.
   b. Cover style: Standard.
   c. Cover material: Standard.
   d. Sensor style: Spring loaded.
   e. Element: Dual, ungrounded.
   f. Element length: Sized to suit thermowell.
   g. Leads: 2-wire chromel-constantan.
   h. Sheath diameter: 1/4” (6 mm).
   i. Sheath material: Type 316 stainless steel.
   j. Extension type: 4" (100 mm) nipple-union-nipple.
   k. Extension material: Carbon steel.
   l. Connection: 1/2” (13 mm) NPT.
   m. Electrical connection: 3/4” (19 mm) NPT.
   n. Other thermocouple types may be acceptable for specific applications with Buyer approval.

4. Thermowells:
   a. Bore: 0.260” (6.604 mm), except as required below for thermowells located in the combustor.
   b. Internal thread: 1/2” (13 mm) NPT.

   1) Thermocouple Terminal Blocks: Wherever possible thermocouple wiring should be wired directly to the control system without intermittent terminal blocks. If junction boxes are necessary for the thermocouple wiring the terminal blocks shall be properly rated for the thermocouple type being terminated on the terminal blocks.

5. Transmitters:
   a. Manufacturer will be Rosemount.
   b. All elements shall have transmitters before going to DCS.
K. Analytical measurement:
   2. Hydrogen sulfide detectors: ISA SP92.01.
   3. Carbon monoxide detectors: ISA SP92.02.
   4. Ammonia detectors: ISA SP92.03.
   5. Chlorine detectors: ISA SP92.06.

L. Control valves:
   1. Furnish control valves and accessories as complete assembly with control tubing, fittings, and
      interconnection wiring.
   2. Verify control valve sizing in accordance with ISA S75.01, as follows:
      a. Minimum flow: Greater than 10% valve travel.
      b. Normal flow: Approximately 50% to 70% valve travel.
      c. Maximum flow: Approximately 90% valve travel.
   3. Verify predicted sound pressure level using ISA S75.17/IEC 534-8-3.
      a. Control valve body outlet velocity shall not exceed mach 0.3.
      b. Predicted sound pressure shall not exceed specified level.
      c. Provide recommendations for mitigation of problem.

M. Verify pressure relieving device sizing for gas, liquid, and steam applications in accordance with
   ASME Boiler and Pressure Vessel Code, Section VIII – Rules for Construction of Pressure Vessels.

2.02 IMPULSE TUBING

A. Tubing:
   1. Process: Water/air/steam/gas below 300 psig and 1,200°F.
      a. Outside diameter: 0.5” (14 mm).
      b. Wall thickness: 0.049” (1.5 mm).
      d. Type: 316 stainless steel.
      e. Construction: Seamless.
   2. Process: Water/air/steam/gas at or above 300 psig, and below 2,500 psig and 1,200°F.
      a. Outside diameter: 0.5” (14 mm).
      b. Wall thickness: 0.083” (2.2 mm).
      d. Type: 316H stainless steel.
      e. Construction: Seamless.

B. Fittings: Type 316 stainless steel compression fittings.

C. Manufacturer: Swagelok, Parker, or equal.

2.03 INSTRUMENT VALVES
A. Low-pressure water, air, gas, and steam below 300 psig and 500°F service:
   1. Type: Ball.
   2. Material: Type 316 stainless steel, ASTM A479.
   3. Pressure rating: 1,500 psig at 100°F.
   4. Internals: Type 316 stainless steel ball, PEEK packing.

B. Steam at or above 300 psig and 500°F and boiler feedwater service:
   1. Type: Ball.
   3. Pressure class: ASME/ANSI B16.34 Class 2500.
   4. Internals: Carbide ball seat and graphoil packing.
   5. Orifice size: 0.375” (10 mm).

C. Manufacturer: Swagelok, Parker, or equal.

2.04 INSTRUMENT MANIFOLDS

A. Type: 2-valve for pressure applications and 3-valve for differential pressure applications.

B. Pressure class: ASME/ANSI B16.34 Class 2500.

C. Material: ASTM A479 Type 316 stainless steel.

D. Internals: Carbide ball seat and graphoil packing.

E. Manufacturer: Anderson Greenwood Co., PGI International, or equal.

2.05 CONTROL AND INSTRUMENT AIR SUPPLY TUBING

A. Tubing: As defined on Instrument Installation Detail Drawing.
   1. Application:
      a. One line for 1 to 4 devices (not including pneumatic actuators).
      b. One line to single pneumatic actuator.
   2. Features:
      a. Outside diameter: 3/8” (10 mm).
      b. Wall thickness: 0.035” (1.0 mm).
      c. Material: ASTM A213; Type 316 stainless steel.
      d. Construction: Seamless.

B. Fittings: Compression, Type 316 stainless steel.

C. Flexible tubing:
   1. Use: Provide for applications between instrument/control valve/controller and stainless steel air supply tubing.
   2. Construction: General purpose synthetic rubber tube, one textile braid reinforcement, with MSHA accepted synthetic rubber cover.
   5. Fitting style: Barbed, as required for application.

D. Manufacturer: Swagelok, Parker, or equal.
2.06 CONDENSATE POTS

A. Provide condensate pot on flow transmitters and drum level impulse tubing installed on steam service.

B. Construction:
   1. Material: Type 316 stainless steel.
   2. Rating:
      a. Design pressure: 4,910
      b. Design temperature: 1,000ºF (538ºC)
   3. Length (from end cap to end cap): 14” (350 mm).
   4. Port configuration:
      a. Vent: Centered on top cap.
      b. Drain: Centered on bottom cap.
      c. To process: Centerline on straight side of pipe 4” (100 mm) from end of vent cap.
      d. To instrument: On opposite side of process connection and 4” (100 mm) from end of drain cap with centerline on straight side of pipe.
   5. Perform hydrostatic test at 1.5 times design pressure for 10 minutes.

C. Materials, per pot:
   1. One 4” (100 mm) Schedule XXH seamless pipe.
   2. Two 4” (100 mm) Schedule XXH butt weld caps.
   3. Four 1/2” (13 mm) 9,000 lb socket-weld weld half couplings.

D. Refer to Instrument Installation Detail Drawing for condensate pot layout.

E. Manufacturer: Fluidic Techniques, Techline Manufacturing, or equal.

2.07 INSTRUMENT ENCLOSURE FOR OUTDOOR INSTALLATIONS

A. Construction: Molded polyurethane or other chemical, ultraviolet light- and fire-resistant material.

B. Enclosure shall fully enclose instrument and manifold.

C. Enclosure shall provide integral 120 volt electric heater with internal thermostat.

D. Mount on same mounting bracket as instrument.

2.08 PREINSULATED TUBING BUNDLE

A. Prefabricated and pre-insulated with impulse tubing or control tubing and tracing mechanism incorporated into a single bundle.

B. Use heat-shrink boots and seals for sealing entry points into instrument enclosure.

C. Use 120V voltage with local thermostat heat tracing.

2.09 ELECTRICAL MATERIALS

A. Rigid steel conduit:
2. Couplings, unions, fittings, and conduit bodies: Threaded type.

B. Flexible liquidtight conduit:
1. Use for short lengths less than 3' (1 m), between rigid conduit or junction box and instrument.
2. Material: Galvanized mild steel strip shaped into interlocking convolutions, with smooth interior surface and outer, waterproof extruded polyvinyl jacket.
3. Fittings: Compression type with tapered hub and synthetic rubber gasket.

C. Wire and cable:
1. Analog signal cable:
   a. Configuration: Twisted pair, shielded, and jacketed.
   b. Insulation: 600-volt, 90ºC, PVC, color-coded to permit identification of each conductor.
   c. Conductors: Stranded copper, 16 AWG.
   d. Shield: Metallized foil or tinned copper braid providing 100% coverage against noise together with 18 AWG stranded tinned copper drain wire.
2. RTD extension wire:
   a. 3-wire system:
      1) Configuration: Twisted triad, shielded, and jacketed.
      2) Insulation: 600-volt, 60ºC, PVC, color-coded to permit identification of each conductor.
      3) Conductors: Stranded copper, 16 AWG.
      4) Shield: Metallized foil or tinned copper braid providing 100% coverage against noise together with 18 AWG stranded tinned copper drain wire.
   b. 4-wire system:
      1) Configuration: 4-conductor twisted, shielded, and jacketed.
      2) Insulation: 300-volt, 90ºC, PVC, color-coded to permit identification of each conductor.
      3) Conductors: Stranded copper, 18 AWG.
      4) Shield: Metallized foil or tinned copper braid providing 100% coverage against noise together with 20 AWG stranded tinned copper drain wire.
3. Discrete signal cable:
   a. Insulation: 600-volt, 90ºF.
   b. Conductors: 16 AWG, stranded copper.

4. Power wire:
   a. Insulation: 600-volt, 90ºF.
   b. Conductors: 12 AWG, stranded copper.

D. Wire and cable tags:
1. Type: Embossed, heat-shrink tubing.

2.10 INSTRUMENT WIRING

A. Provide No. 16 AWG single twisted shielded pair cable for 24-volt dc analog signals in accordance with Section 26 05 00.

B. Provide No. 16 AWG, 600-volt wire for 120-volt ac signals in accordance with Section 26 05 00.
C. Provide No. 12 AWG, 600-volt wire for 120-volt ac power circuits in accordance with Section 26 05 00.

2.11 INSTRUMENTS AND CONTROL DEVICES

A. Instrument and control devices shall be rated according to applicable design process temperatures and pressures.

B. Pressure transmitters
   1. Type: Absolute, differential, and/or gauge.
   2. Output: 4 – 20 mA with digital signal based on HART protocol.
   3. Process flange type: Coplanar or traditional as required by the service.
   4. Materials of construction: Type 316 stainless steel flange and drain/vent.
   5. Isolating diaphragm: Type 316L stainless steel.
   6. O-ring: Glass-filled PFTE.
   7. Fill fluid: Silicone.
   8. Housing material: Polyurethane-covered aluminum.
   9. Mounting: Bracket for 2" (50 mm) pipe stand.
   10. Options:
       a. LCD display.
       b. Calibration data sheet.
   11. Manufacturer: Rosemount Model 3051C, or equal.

C. Pressure switches
   a. No pressure switches will be used.

2. Manufacturer: Ashcroft, or equal.

D. Pressure gages:
   1. Type: Direct reading.
   2. Mounting: Local.
   3. Dial: 4-1/2" (114 mm).
   8. Lens: Glass.
   9. Nominal accuracy: ±0.5%.
   10. Materials:
       a. Pressure element: Bourdon tube.
       b. Element material: Type 316 stainless steel.
       c. Socket material: Type 316 stainless steel.
   11. Connection: 1/2" (13 mm) NPT lower.
   15. Manufacturer: Ashcroft, 3D/Sierra Precision, Ametek/US Gauge, or equal.

E. Differential pressure (DP) gages:
   1. Element: Diaphragm.
   2. Dial: 4-1/2" (114 mm).
   3. Color: Black on white.
   5. Nominal accuracy: ±2%.
6. Actuator: Convoluted diaphragm.
8. Connection: 1/4" (6 mm) NPTF, In-line.
10. Materials:
   b. Element: Buna-N.
11. Manufacturer: Ashcroft Model 1133, or equal.

F. Flow indicators:
1. Type: Rotor.
   a. Body: A216 WCB.
   b. Process connections: As required.
   c. Window: Tempered borosilicate.
   d. Seal gasket, for window: Neoprene gasket.
   e. Manufacturer: Jacoby-Tarbox, or equal.
2. Type: Rotameter.
   b. O-ring: Buna-N.
   c. Float: Stainless steel.
   d. Features specified As Required:
      1) Process connections.
      2) Flow range.
   e. Manufacturer: Dwyer VFC, or equal.

G. Flow indicators (adjustable):
1. Type: Rotameter with valve.
3. O-ring: Buna-N.
5. Accuracy: 3% of full scale.
6. Features specified As required:
   b. Flow range.
7. Manufacturer: Dwyer RM, or equal.

H. Flow measurement (differential pressure):
1. Type: V-Cone.
   a. Beveled ends.
   b. In-line.
   c. Features specified As required:
      1) Size.
      2) Pipe schedule.
3) Materials of construction.
4) End connections.
5) Pressure tap fittings.
6) Beta ratio.
7) Turndown.

d. Manufacturer: McCrometer VB series.

2. Type: Flow nozzle.
a. Weld-end flanges.
b. Features specified As required:
   1) Size.
   2) Pipe schedule.
   3) Materials of construction.
   4) End connections.
   5) Pressure tap fittings.
c. Manufacturer: Vickery-Simms, Daniel, or equal.

3. Type: Orifice.
a. Plate edge thickness: Bore and bevel.
b. Features specified As required:
   1) Size.
   2) Process end connections.
   3) Plate thickness.
   4) Materials of construction.
   5) Bore diameter.
   6) Beta ratio.
c. Provide paddle type handle with following stamped on handle:
   1) Tag number.
   2) Line size.
   3) Flange rating.
   4) Orifice bore.
   5) Plate material.
e. Alternate: Rosemount 3051 S series compact flow / flow conditioning orifice flow meters

I. RTD assemblies:
1. Sensors:
a. RTD: 3 or 4 wire, 100 Ohm platinum, conforming to IEC 751 Class B.
b. Cover style: Standard.
c. Cover material: Standard.
d. Sensor style: Spring-loaded.
e. Element: Double.
f. Element length: Sized to suit thermowell.
g. Lead configuration: See Section 40 91 00-2.09.
h. Sheath diameter: 1/4" (6 mm).
i. Sheath material: Rated for high temperatures up to 1,070°F (577°C) or above.
j. Extension type: 4" (100 mm) nipple-union-nipple.
k. Extension material: Carbon steel.

l. Connection: 1/2" (13 mm) NPT.

m. Electrical connection: 3/4" NPT.

J. Thermowells:
   1. Features specified As required:
      a. Material of construction.
      b. Process connection.
      c. Insertion length "U".
      d. Lagging Extension "T".
      e. Shank style.

   2. Bore: 0.260" (6.604 mm).
   3. Internal thread: 1/2" (13 mm) NPT.
   4. Stainless steel plug with captive chain.
   5. Manufacturer: Thermo Electric, Pyco, Conax-Buffalo, or equal.

K. Temperature gages with thermowells:
   1. Gages:
      a. Type: Bimetal
      b. Mounting: Adjustable angle (local).
      c. Dial: ½" LCD Digits.
      d. Case: High Density Plastic Enclosure
      e. Stem material: Stainless steel.
      f. Nominal accuracy: ±1%.
      g. Stem connection: 1/2" (13 mm) NPT union.
      h. Stem diameter: 1/4" (6 mm).
      i. Options: Stainless steel tag.
      j. Range: -45/150°C.
      j. Manufacturer: Weiss Vari-angle Digital Thermometer

   2. Thermowells:
      a. Features specified As required:
         1) Material of construction.
         2) Process connection.
         3) Insertion length "U".
         4) Lagging extension "T".
         5) Shank style.
      b. Bore: 0.260" (6.604 mm).
      c. Internal thread: 1/2" (13 mm) NPT.

L. Control valves
   1. Maximum allowable sound level shall not exceed 85 dBA at 3 feet for valves that are in continuous operation.
   2. Vacuum service: valves shall have packing designed to minimize air leakage into valve with external pressures of 15 psia and full vacuum on valve interior.
   3. Features specified As required:
      a. Size.
      b. Type.
      c. Rated Cv.
      d. End connections.
      e. ANSI class rating.
      f. Body.
      g. Fail position.
      h. ANSI Class seat tightness.
      i. Valve characteristic.
      j. Upstream and downstream line sizes.

4. Actuators:
   a. Type: Pneumatic spring diaphragm.
   b. Size: As required for application.
   c. Spring type: As required for application.
   d. Air connections: 1/4” (6 mm) NPT standard.
   e. Model:
      1) Rotary: Type 1051 or 1052, as required for application.
      2) Sliding stem: Types 657 and 667, as required for application.
   f. Manufacturer: Fisher.

5. Positioners:
   a. Style: Advanced diagnostics.
   c. Display: With display.
   d. Gages: With tri-scale gages.
   e. Communications: HART protocol.
   f. Agency approvals: None.
   g. Manufacturer: Fisher DVC6200 Series, or technically compliant equal.

6. Options:
a. Air set with output gages.
b. Factory installed and tested filter regulator assembly designed to meet requirements of complete valve assembly.
c. Swagelok stainless steel tubing and fittings.
d. Handwheel: None.
e. Valve trains shall be delivered as completely tested and assembled products.

7. Manufacturer: Fisher/Emerson, or equal.

M. Relief valves:

1. Valve features As required:
   a. Inlet and outlet connections:
      1) Size.
      2) End connections.
      3) ANSI Class rating (if applicable).
   b. Materials of construction.
   c. Orifice size.
   d. Levers.

2. Manufacturer: Dresser/Consolidated, TYCO/Anderson Greenwood/Crosby, or equal.

2.12 INSTRUMENT IDENTIFICATION

A. Each instrument and control device shall have a tag permanently attached to case with following applicable information:
   1. Tag number.
   2. Manufacturer’s name.
   3. Model number.
   4. Serial number.
   5. Operating range.
   6. Calibration setting/range.
   7. Power rating.

B. Each control valve and actuator shall have stainless steel nameplate, permanently fastened to valve body or actuator with following as applicable:
   1. Manufacturer’s name, model number, and serial number.
   2. Valve action on air failure.
   3. Operating range and bench setting.
   4. Body and trim size.
   5. Body and trim materials.
   7. Type of packing and lubricant.
   8. Flow arrow indicating direction of flow.
   9. Tag number.

PART 3 EXECUTION

1) K. Hanzon
2) A. Szalaj
PART 1  GENERAL

1.01  SECTION INCLUDES

A. Control panels/enclosures completely assembled with instruments and control devices mounted and wired for Seller's packaged equipment.

B. Provide and mount instruments as applicable for each panel/enclosure and as specified herein.

C. Mount and wire programmable logic controller (PLC), I/O chassis, and LCD-based graphic interface in panels/enclosures (if required).

D. Performance tests.

1.02  SUBMITTALS

A. Submit information relating to instrumentation and control devices referencing instrument tag number listed on submittal documents.

1. Control panel/enclosure:
   a. For review:
      1) Panel exterior general arrangement drawings showing location of surface and flush-mounted equipment.
      2) Panel interior arrangement drawings including:
         a) Locations and identification of terminal blocks.
         b) Locations and identification of racks/chassis and equipment mounted within.
         c) Arrangement of other equipment mounted inside panel identified by instrument tag number.
      3) Exterior panel wiring interface termination diagrams.
      4) List of nameplate legends and sizes for panel-mounted equipment.
   b. For information only:
      1) Schematics and wiring diagrams identifying internal to system terminals, circuits, color of wire, and cable/wire numbers. Cable and wire numbers for external wiring will be assigned by others. Wire, and terminal numbers for panels shall be assigned by panel provider. Wire, and terminal numbers shall be instrument tag number oriented.
      2) Provide heat gain calculations for each panel/enclosure with all components energized and in operation. Calculations shall be based on extreme ambient temperatures defined within specifications. High temperature calculations shall be performed with exterior panels in full exposure to sun. Provide adequate cooling or heating for any panel in which internal cabinet operating temperature is above maximum temperature rating or below minimum temperature rating of any component mounted within enclosure.

2. Panel-mounted instruments:
   a. For review: Manufacturer's data and/or specification sheets for control and instrument items, showing design parameters, equipment catalog designations, calibration range, features and options provided. All sheets shall be identified with corresponding instrument tag numbers.
   b. For information only: Tabulation of equipment including accessories listed separately where not assembled with equipment item. Tabulation shall include item number, service equipment description, or identification, part or catalog number and other information helpful to installation of equipment and coordination of Project.

B. Factory Performance Test Procedure.

C. Closeout submittals:
   1. Operation and maintenance manual:
a. Complete instruction manuals and parts lists covering installation, operation, and maintenance of panel-mounted devices. Manuals shall include interface drawings defining terminal numbers and functions for interface with other instruments and equipment.

b. Schematic and wiring diagrams for each panel/enclosure. Show color of wire, termination points, terminal numbers, cable and wire numbers.

2. Project record documents: “As-built” schematics and wiring diagrams defining terminals, cables, and wire numbers as defined above.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Prior to shipment, provide to Buyer storage and handling requirements to ensure availability of proper storage space and that procedures are followed.

B. Ship control panels as recommended by control panel/enclosure manufacturer. Ensure packaging is suitable for transport via an oceangoing vessel.

C. Provide removable eye bolt lifting lugs for large panels and suitable skids for safe handling.

D. Remove rack-mounted instruments, controllers, recorders, and indicators that could be damaged by shipment and package in original shipping cartons.

1.04 SITE CONDITIONS

A. Indoor applications: Refer to Section 3418.00 31 00

B. Outdoor applications: Refer to Section 3418.00 31 00.

C. Equipment enclosures shall be rated in accordance with Section 26 05 00.

D. Electrical power source: 120-volts ac, 60 Hz.

1.05 MAINTENANCE

A. Panel manufacturer shall supply separately packaged spare parts of following items:
   1. Fuses: 100% of each rating furnished with control equipment and used internally within the panel/enclosure for circuit protection including, but not limited to, miscellaneous fuses on controllers, recorders, and indicators. Minimum of one standard package.
   2. Indicating lamps: 10% of each type furnished with control equipment. Minimum of one standard package.
   3. Relays: 10% of each type furnished with panel/enclosure. Minimum of one.

PART 2 PRODUCTS

2.01 FABRICATION

A. Size: Sufficient to house terminal blocks, wireways, power supplies, racks, chassis, and instruments required for each application. Provide 25% additional space for future expansion.

B. Oil-resistant gasket attached with oil-resistant adhesive.

C. Provide each panel/enclosure with industrial corrosion inhibitor emitters of sufficient size and quantity to protect contents of enclosure size selected. Emitters shall contain additional red metal inhibitors to protect brass and copper material in addition to ferrous metals.

D. Provide adequate cooling by means of air conditioners, pneumatic vortex coolers, blowers, exhaust fans, or sun shade, as necessary, for any panel in which internal cabinet operating temperature
exceeds rating of any component mounted within enclosure. Thermostat shall be used to control internal temperature.

E. Provide adequate heating by means of electric heater and thermostat for panel in which internal cabinet temperatures may fall below operating temperatures of component mounted within enclosure or in which harmful condensation may develop.

F. Provide "data pockets" for Drawing storage on inside face of panel.

G. Subpanels: Provide for full surface mounting of terminal blocks, wireways, power supplies, racks, chassis, and instruments.

H. Free-standing panels:
   1. Panels shall mount on 3" concrete pad provided by others.
   2. Construct control panel in accordance with manufacturer's standard, subject to Buyer's review.
   3. Control panel shall be self-supporting with angle iron or plate framework as necessary to obtain proper stiffness and support.
   4. Fabricate control panel of 12-gage carbon steel plate with all-welded construction throughout. Welds shall be ground smooth, corners shall be rounded, and weld spatter cleaned. Corner construction shall be minimum of 1/8" inside radius. Control panel construction shall meet NEMA 12 standards, unless otherwise indicated.
   5. Surface of control panel shall be free from mars and defects. Finished panel surfaces shall be flat within 1/16" in 6'-0" and be smooth with rounded edges. Finished panel surfaces shall be 3/16" thick. Instrument cutouts and drilling shall be straight and true.
   6. Provide 10-gage full height rear front access doors. Access doors shall have triple-point latch, stainless steel handle and lock, full length stainless steel "piano" type hinge, and sponge rubber gaskets. Door shall be supplied with devices to hold door in 105° position when fully opened.
   7. Provide lower, full-width, rectangular subpanel for surface mounting of programmable controller, other surface-mounted instruments, wiring troughs, and terminals strips.
   8. Provide full-length, side-mounted subpanels for installation of terminal strips.
   9. Base of control panel shall be adequately reinforced to permit anchoring to concrete pad.
   10. Supply 4 identical master keys which will operate all locks of each control panel.

I. Surface-mounted panels:
   1. Type: NEMA 4 steel, NEMA 4X stainless steel, as required for application, seam-sealed construction with no holes or knockouts and with stainless steel collar studs for mounting subpanels.
   2. Size: As required for application as specified above.
   3. Provide Type 316 stainless steel hasp for padlocking.
   4. Provide full size subpanel.
   5. Color:
      b. Interior: Flat, non-glare white.

J. Auxiliary local control panels:
   1. Type: NEMA 4 steel, NEMA 4X stainless steel, or NEMA 4X fiberglass-reinforced, as required for application, seam-sealed construction with no holes or knockouts and with stainless steel collar studs for mounting subpanels.
   2. Size: As required for application as specified above.
   3. Provide with internal swing-out panel kit form flush-mounted selector switches, pushbuttons, pilot lights, and digital indicators as required per application.
   4. Provide with window kit for viewing of flush-mounted devices.
   5. Provide with stainless steel hasp for padlocking windowed door.
   6. Color:
      b. Interior: Flat, non-glare white.

2.02 PANEL-MOUNTED INSTRUMENTATION

A. Control relays:
   1. Function: General logic hardware interlocks.
   a. Type: Plug-in.
   b. Construction: Continuous duty.
   c. Coil voltage: 120-volt ac, 60 Hz.
   d. Switch configuration: 3-SPDT.
   e. Indication: Mechanical or LED to indicate energized relay.
   f. Switch rating: 10 amperes at coil voltage.
   g. Mounting: Socket for DIN-rail mounting.
   h. Manufacturer: Tyco Potter & Brumfield KUEP.

B. Selector switches:
   1. Type: Non-illuminated.
   2. Configuration: 4-position, 3-position, and 2-position; as required for application.
   3. Contact rating: 10 amperes at 120-volts ac, 60 Hz.
   4. Operator function: Maintained Spring return from left Spring return from right Spring return from both directions (3-position only)
   5. Legend plates: As required for application subject to Buyer's review.
   6. Manufacturer: Allen-Bradley, Series 800T, or equal.

C. Pilot lights:
   1. Type: Standard push-to-test.
   2. Input: Type, 130-volt ac/dc, LED, full voltage.
   3. Lens color:
      a. Red: Danger, run, or open.
      b. Amber: Shutdown, caution, pre-alarm, or abnormal.
      c. Green: Stop, closed, or satisfactory.
      d. White: Power available, ready.
      e. Blue: Status.
   4. Legend plates: As required for application subject to Buyer's review.
   5. Manufacturer: Allen-Bradley, Series 800T, or equal.

D. Pushbuttons:
   1. Type: Non-illuminated.
   2. Configuration: Single-operator, number of poles as required for application.
   3. Contact rating: 10 amperes at 120-volts ac, 60 Hz.
   4. Operator:
      a. Flush head: Start applications.
      b. Extended head: Stop applications.
      c. Mushroom head: Emergency stop applications.
   5. Lens color:
      a. Red: Danger, run, or open.
      b. Green: Stop, closed, or satisfactory.
c. White: Power on.
6. Legend plates: As required for application subject to Buyer's review
7. Manufacturer: Allen-Bradley, Series 800T, or equal.

E. Intrinsically safe barriers:
1. Function: Isolate switches in hazardous areas.
2. Type: Isolated switching.
3. Hazardous area classifications: Class I, II, III; Groups A through G.
4. Power required: 120-volts ac, 60 Hz.
7. Inputs: One dry contact per channel.
8. Outputs: SPDT relay contact per channel.
9. Manufacturer: Crouse Hinds, Model SA 23025 M 103, or equal.

F. Provide 1 or more 24-volt dc power supply, as necessary, within each panel to power field transmitters and PLC I/O. Amperage shall be 200% of required capacity.

2.03 FACTORY INTERNAL WIRING

A. Provide complete factory wiring of control cabinet and equipment mounted thereon.

B. Provide separate circuits from power distribution panel for:
   1. UPS feeding PLC system and communication devices.
   2. Instrumentation and control devices.
   3. Lighting and service outlets.

C. Install continuous wire from terminal to terminal, splices will not be acceptable.

D. Wiring and cable shall meet UL 1581 VW-1 flame test.

E. Wire and cable:
   1. Analog signal cable:
      a. Configuration: Twisted pair, shielded, and jacketed.
      b. Insulation: 300-volt, 60ºC, PVC, color-coded to permit identification of each conductor.
      c. Conductors: Stranded copper, 18 AWG.
      d. Shield: Metallized foil or tinned copper braid providing 100% coverage against noise together with 20 AWG stranded tinned drain wire.
   2. Power wire:
      a. Rating: 600-volt, 90ºC, PVC insulation/jacket, Type MTW.
      b. Conductors: Stranded copper, 12 AWG.
   3. Discrete signal wire:
      a. Rating: 600-volt, 90EC, PVC insulation/jacket, Type MTW.
      b. Conductors: Stranded copper, 18 AWG.
   4. Power and discrete signal wire insulation color:
      a. BLK: Line voltage.
      b. BRN: Line voltage/fused.
      c. RED: 120-volt control ac.
      d. ORG: 24-volt control ac.
      e. YEL: Caution/may be live from remote power source.
      f. GRN: Ground.
      g. BLU: Dc negative.
      h. VIO: Dc positive.
      i. WHT: Neutral at GND potential.
F. Group and route wire/cables from terminal blocks to panel-mounted instruments in separate wireways as follows:
   1. Low-voltage/low current dc analog signals (30-volts/50 mA or lower).
   2. High-voltage dc alarm signals (48-volts or greater).
   3. Low-voltage ac control signals (120-volts or lower).
   4. High-voltage ac power signals (greater than 120-volts).

G. Wiring interfaces:
   1. External connections:
      a. Install dedicated terminal strips for analog, discrete, and power signals.
      b. Provide manufacturer's standard connectors for communications, digital data, and multiplexed signals.
      c. Provide surge suppressor terminal blocks for analog and discrete signals that leave building structure:
         1) Analog signal blocks: Voltage rating 24-volt ac/dc; Allen Bradley 1492-HM2K024 Series, or equal.
         2) Discrete signal blocks: Voltage rating 120-volt ac/dc; Allen Bradley 1492-HM2K120 Series, or equal.
      d. Provide intrinsically safe barriers for applications where field instruments are not rated as explosionproof for use in hazardous classified areas. Crouse-Hinds SPEC 504, or equal.
   2. Provide separate terminal strips and wireways for 120-volt ac and 24-volt dc circuits.
   3. Terminal block requirements:
      a. Type: High-density.
      b. Voltage: 600-volt.
      c. Wire range: 30 AWG to 12 AWG.
      d. Termination: Screw clamp compression with pressure plate.
      e. Mounting: Rail-mounted with end anchors and barriers.
      f. Spare: Provide greater amount of 20% or 6 terminals per terminal strip
      g. Manufacturer: Allen Bradley 1492-H1, or equal.
   4. Terminate maximum of 2 wires on single connect point.
   5. Wire PLC network communication cables point-to-point rather than terminating on interposing terminal blocks.
   6. Install power distribution blocks to parallel feed to power control devices. Parallel wiring from instrument to instrument not acceptable.
   7. Provide plug-in strip for ac supply power to devices requiring ac power via power cord.
   8. Circuit protection:
      a. Install individual circuit breakers for protection of control panel power supply circuits as identified above. Allen Bradley 1492CB1G Series, or equal.
      b. Group circuit breakers on separate terminal strip away from low-voltage instrumentation circuitry.
      c. Provide fuses or circuit breakers for protection of individual instrumentation circuits. Instrumentation circuits for field-mounted instruments may be combined in logical groupings of no more than 10 devices/signals.
         1) Fuses: Allen Bradley 1492-H6 Series, or equal.
         2) Circuit breakers: Allen Bradley 1492-GH Series, or equal.
   9. Provide 8 AWG internal copper grounding bus for ground connections.

H. Wire tags:
   1. Type: Embossed, heat-shrink tubing. Fiber tape tagging not acceptable.
   3. Identify both ends of wires and/or cables with permanent wire marker.

I. Service equipment:
   1. Fluorescent lighting fixtures of sufficient size and quantity to provide 30 to 50 foot-candles of illumination within panel. Wire to UL-approved switch mounted inside panel.
2. Duplex, 120-volt ac, 3-wire grounded type convenience outlets. Provide 1 duplex receptacle per 12 sq. ft. of subpanel area. Service outlets shall be powered from separate voltage source than instrumentation and PLC equipment, as defined above.

2.04 NAMEPLATES
A. Provide permanent nameplates for devices mounted on or within panels. Provide separate nameplates. Standard nameplates included with instruments not acceptable. Plastic tape labeling not acceptable.
B. Type: Instrument nameplates shall be fabricated of laminated plastic, not less than 1/16" thick white Bakelite engraving stock with black core.
C. Size: Outside panel surface shall be 1" x 2", minimum.
D. Lettering: Engraved, approximately 3/16" high, minimum, subject to RESIDENT ENGINEER's review.
E. Attach with sheet metal screws after painting is complete. Glue adhesive not acceptable.

2.05 PAINTS AND FINISH
A. Surfaces shall be commercial blast cleaned in accordance with SSPC SP6.
B. After preparation of surfaces, pits or indentations shall be filled with a 100% solid catalyzed epoxy putty compound.
C. After hardening of putty filler, filled areas shall be sanded smooth. Entire exterior surface shall be smooth and uniform to receive paint.
D. Manufacturer's standard interior and exterior paint shall be acceptable as primer coat.
E. Prepare interior and exterior surfaces for finish coat of paint in accordance with manufacturer's instructions.
F. Color:
   1. Interior and subpanels: Flat, nonglare white.
   2. Exterior: Gray.
G. Spray-apply paint to produce smooth, uniform coat, free of defects. SSPC PA-1 shall apply.
H. Each coat shall be properly cured according to manufacturer's instructions before application of succeeding coats.

2.06 SOURCE QUALITY CONTROL
A. Seller shall be responsible for hardware provided and shall notify Buyer, in writing, when panel/enclosure control systems are considered complete, in good operating condition, and ready for performance testing.
B. Factory performance tests:
   1. Perform testing and inspection prior to shipment of control equipment at manufacturing facility.
   2. Testing in preparation for inspection shall include, but not be limited to following:
      a. Confirm point-to-point wiring by continuity tests with written checklist indicating satisfactory results after final assembly and wiring.
      b. Energize control circuits, simulate analog and discrete signals.
      c. Verify hand switches, pushbuttons, and pilot light operations.
d. Check control circuits for proper sequence of operation and interlocking functions.
e. Test instruments over full operational range. Prove instruments to be within published specifications and accuracy. Instruments shall be tested individually and where applicable, as a system. Testing shall be by simulated field signals.

3. If equipment or system fails to perform properly, make necessary corrections, including replacement, at no cost to Buyer as follows:
   a. Correct wiring changes including changing terminal block and/or wire tags.
   c. Retest equipment verifying deficiencies are corrected.

4. At completion of testing, notify Buyer of completion of testing and readiness for inspection.

C. Inspection:
1. Notify Buyer, in writing, 10 days prior to completion of control panels/enclosures final testing. At their option, Buyer may witness final factory inspection.
2. Coordinate between all concerned parties and establish schedule for inspection. Give minimum 10-day notice to all parties.
3. Written test procedures shall be submitted prior to witness testing. Procedures shall be used for final testing.
4. Upon satisfactory completion of testing, final inspection will be made by Buyer.
5. If system fails to perform properly, make necessary changes and adjustments to equipment at no cost to Buyer as defined above, and notify Buyer when ready for reinspection.
6. Reinspection schedule shall be same as initial inspection procedures.
7. If inspection is substantially correct but with minor defects, verify deficiencies are corrected in writing to Buyer without need for additional witness testing.

PART 3 EXECUTION

NOT USED

END OF SECTION

1) K. Hanzon
2) A. Szalaj
PART 1  GENERAL

1.01  SECTION INCLUDES

A.  Requirements for submittal of recommended monitoring and control strategies necessary for safe and efficient operation of the Seller’s equipment and systems.

B.  This section is based on the Buyer’s intent to integrate direct control and monitoring of as many plant subsystems as possible into the overall plant DCS (furnished by others). For packaged equipment with proprietary controllers or systems where remote DCS control is not feasible or advisable, the DCS will provide a supervisory monitoring and/or control function utilizing digital communication links or hardwired I/O points with the Seller furnished local dedicated control system.

C.  Systems which will be controlled from the plant DCS will include as a minimum:
   1.  Burner Management System (BMS)
   2.  Boiler Combustion Control System (CCS)
   3.  Air Quality Control Systems (AQCS)
   4.  Sootblower Control Systems
   5.  Other boiler related subsystems
   6.  Steam Turbine
   7.  Condensing Equipment

D.  Seller’s participation in DCS Factory Acceptance Testing for portions of the DCS that control Seller’s equipment, including travel to the site of the FAT to witness actual testing.

1.02  WORK BY OTHERS

A.  Field wiring from Buyer’s distributed control system (DCS) to remote or shipped loose instruments, control devices, panels, and junction boxes supplied under this Contract.

B.  Configuration of Buyer’s DCS for required hardware interfaces and programming of functional logic into DCS.

C.  Plant DCS control system platform.

1.03  INFORMATIONAL SUBMITTALS

A.  Descriptive literature on Seller’s related systems hardware and functional operation.

B.  Special procedures submittals: Detailed performance criteria and testing procedures used to determine satisfactory operation meeting system functional performance criteria.

1.04  ACTION SUBMITTALS

A.  Control narrative descriptions for each operational system and piece of furnished equipment. Descriptions shall include:
   1.  All startup and shutdown sequences with permissive/Interlock lists.
   2.  Analog control loop operation
   3.  All operator interactions required
   4.  Load changing operations
   5.  Redundancy requirements and failover actions
   6.  Emergency procedures and responses
   7.  Alarm responses
   8.  Trouble shooting procedures

Rev. 0
9. Operational interlocks, including those required by NFPA

B. Functional logic diagrams as required to supplement narrative descriptions

C. I/O list in Microsoft Access or Excel format.
   1. Identify all system related instrument and control I/O points using assigned tag numbers and
descriptions coordinated with control narratives and functional logic diagrams
   2. Include engineering units, calibrated ranges, and discrete contact state descriptions

D. Seller-recommended system operator graphics layouts.

E. Alarm and set point lists.

F. Available parameter lists for all local controller digital links to the plant DCS.
   1. Include applicable ranges, set points, and addressing
   2. Include all applicable link setup parameters such as IP addresses and protocols.

G. Quality assurance: Detailed performance criteria and testing procedures if required to determine
satisfactory operation meeting system functional performance criteria.

1.05 CLOSEOUT SUBMITTALS

A. Record documents, which accurately reflect status of all submitted documents after review and
witness testing:

1.06 REVIEW AND TESTING

A. Seller shall participate in the review of all implemented control logic and graphic screen submittals
from the DCS supplier to confirm conformance with Seller’s equipment control and safety
requirements.

B. Seller will review graphics screens prior to FAT to make certain that required HMI functions and
safety requirements are available.

C. Seller will attend the FAT for the purpose of confirming control logic conformance to the Seller
recommended functions.

D. Seller shall attend DCS supplier’s Factory Acceptance Test (FAT) and confirm satisfactory
implementation of Seller’s required control logic functionality.

E. Seller shall provide adequate and timely field startup assistance to resolve any issues which arise
during the commissioning and initial operation of the Seller’s equipment.

PART 2  PRODUCTS

PART 3  EXECUTION

    NOT USED

END OF SECTION

1) K. Hanzon
2) A. Szalaj
PART 1  GENERAL

1.01 SECTION INCLUDES

A. Design, furnish, and deliver one (1) heat recovery surface condenser, accessories and auxiliary equipment, instruments, and safety devices in conjunction with Seller provided ACC.

1.02 WORK BY OTHERS

A. Labor, superintendence, materials, and equipment necessary for unloading, erecting, and commissioning condenser.

B. Foundation design including anchor bolt supply.

C. Piping external to condenser.

1.03 QUALITY ASSURANCE

A. Manufacturer's qualifications:
   1. Proposed condenser shall be a regularly catalogued product of manufacturer.
   2. Manufacturer has prime responsibility for vendor surveillance and evaluating and monitoring implementation of quality assurance program of subvendors.
   3. Owner reserves right to require revision to manufacturer's quality assurance program if deemed ineffective or inadequate in providing acceptable quality control.

1.04 SYSTEM DESCRIPTION

A. Design requirements:
   1. Design and construction of equipment shall conform to HEI Standards for Steam Surface Condensers.
   2. The required performance for the condensing system is specified in the Data Sheets in Section 00 43 33.

B. Arrangement:
   1. Steam turbine exhaust arrangement: Axial, however the ACC duct will connect to the turbine exhaust and a duct tee will direct the exhaust to the condenser.
   2. Single-pressure.
   3. Number of shells: 1.
   4. Number of tube passes: as required.
   5. Storage type: Condensate drains Tank.

C. Not to exceed dimensions (exact dimensions to suit design) are provide in Exhibit A – General Arrangement Drawings:

PART 2  PRODUCTS

2.01 FABRICATION

A. Shell:
   1. Design pressure: full vacuum to 15 psig.
   2. Steel: ASTM A516 Grade 70.
   3. Corrosion allowance: 1/16" (2 mm).
   4. Design adequately for conditions under which unit shall operate and shall remain tight under any operating vacuum.
   5. Design for differential expansion between shell and tubes without leakage of circulating water into steam space.

B. Neck:
1. Arrangement shall suit turbine, turbine foundation, and ACC duct.
2. Expansion joint:
   a. Type: One-piece, corrugated element, with internal sleeve.
   b. Design: Not less than 2 corrugations and design to limit compression forces on associated equipment as required by Sellers design.
   c. Materials: End pieces connecting to turbine and condenser shell, carbon steel; all other parts, stainless steel.
3. Access:
   a. Inspection doors: Hinged, not less than 24" (600 mm) diameter.

C. Water boxes:
1. Design pressure, psig: 60.
2. Hydrostatic test pressure, shall be 30 percent higher than design pressure.
3. Steel: ASTM A516 Grade 70.
4. Corrosion allowance: 1/16" (2 mm).
5. Shell attachment: Bolted and gasketed.
6. Inspection doors:
   a. Provide 2 per water box to allow inspection of tube ends.
   b. Type: Hinged, not less than 24" (600 mm) diameter.
7. Provide lifting lugs on each water box.
8. Provide threaded holes and jack bolts for releasing water box inspection doors.
9. Provide internal brackets to support temporary scaffold. Brackets shall be separated by 4' (1.2 m) intervals of height.
10. Shop coat water boxes with manufacturer's standard heavy-duty lining suitable for circulating water chemistry specified herein.
11. Size for complete waterside draining in 15 minutes.
12. Provide cathodic protection anodes. Quantity and size shall be determined by Contractor.

D. Tube support plates
2. Corrosion allowance: 1/16" (2 mm).
3. Secure to shell in accordance with manufacturer's standard procedure.
4. Construct tube holes in accordance with manufacturer's standard procedure.
5. Tube support spacing shall comply with method outlined in HEI Standard for Steam Surface Condensers.

E. Tube sheets:
2. Corrosion allowance: 1/16" (2 mm).
3. Weld to shell independently of bolts used for connecting shell to water boxes, so water boxes can be removed without disturbing joint between tube sheet and shell.
4. Tubesheet and tube support plate holes shall be drilled in accordance with the tolerances established in the HEI "Condenser Construction Standards."
5. Provide means for detecting circulating water leakage into steam space at each tube sheet.
6. Design to withstand concurrent loads imposed by steam space water box pressure, water box nozzle reactions, water box dead weight, and transient water surge pressure.

F. Tubes:
1. The tube/tube bundle shall be designed to withstand all stresses (mechanical, thermal, operational, etc.) during startup, shutdown, and normal operation of the condenser.
2. The tubes shall be arranged to be self-draining..
3. Tubes shall be rolled into the tubesheets.
4. The tubes shall be seamless or welded and shall be manufactured from the alloys specified and according to the ASTM designations.

G. Condensate drains tank:
1. The condensate drains tank shall contain condensate equivalent to 3 minutes of design condensate flow between normal water level and Low-Low (pump trip) water level. Design flow shall be the combined flow of the ACC and condenser.
2. Design with adequate space between water surface and bottom of tube bundle to permit steam flow under tubes for condensate reheating.

3. Provide baffles to prevent surging of drains tank level and dead zones. Provide cutouts where required to ensure complete drainage.

4. Drain connections shall permit drainage of hot well compartment and sumps in 30 minutes or less.

5. Design for minimum entrance losses of condensate into condensate pump suction piping.

6. Provide 3” (75 mm) high dirt dam and screens at inlet to each outlet sump inlets to retain solids.
   a. Size screens to protect condensate pumps.
   b. Screen opening shall not exceed 1-1/2” (38 mm).

7. Provide anti-vortex vanes at each hot well sump.

H. Supports:
   1. Weld to shell at load points.
   2. Arrange for solid, bolted mounting. Bolting through bottom of hot well not acceptable.

I. Connections and openings:
   1. Provide connections as required by installation including, but not limited to, Terminal Point List included in Section 01 18 00.
   2. Arrange connections to suit specific service and be accessible; subject to Buyer’s review. Location of miscellaneous connections will be provided by Buyer upon receipt of preliminary condenser arrangement drawing.
   3. Provide water and flashing drain inlet connections with stainless steel baffles to protect against direct impingement on condenser tubes.
   4. As a minimum, provide internal provisions specified on Terminal Point List. Review connection conditions and provide additional provisions as required.
   5. Provide reinforcement pad for connections where indicated in Condenser Connection List.

J. Locate gage, control and alarm device connections so true conditions are indicated, free from velocity, ramming or eddy effects.

2.02 SHOP ASSEMBLY

A. Shop-assemble, to the greatest extent possible, to determine components can be fitted and aligned properly on final assembly. Match-mark to assure proper field alignment.

B. Nozzles, sleeves, thermal sleeves, and baffles shall be shop-welded to condenser shell except where not practical due to packing and shipping considerations. Perforated distribution pipe may be shipped loose for field welding.

C. Box or otherwise suitably prepare parts for shipment to prevent damage in handling and transit. All equipment shall be packaged for shipment via oceangoing vessel.

D. Piping and other openings shall be plugged or capped to prevent entrance of foreign material.

E. Exposed surfaces shall be thoroughly cleaned and external surfaces painted with one coat of shop primer before leaving factory except that machined surfaces shall be thoroughly coated with water soluble rust preventative.

PART 3 EXECUTION

3.01 MANUFACTURER’S FIELD SERVICES

A. Provide services of field service engineer in accordance with Section 01 43 33.

3.02 NONDESTRUCTIVE EXAMINATIONS (NDE)

A. Perform visual examination before other NDE. Visual examination shall be performed by personnel certified to AWS QC1 requirements.
B. NDE methods, acceptance criteria, and additional general requirements shall be in accordance with applicable fabrication code and this specification.

C. NDE shall be by personnel qualified to Level II or Level III requirements of NDT SNT-TC-1A

D. Radiographic examinations required shall be performed in accordance with requirements of appropriate fabrication code or this specification and shall comply with acceptance criteria of ANSI B31.1 or as specified herein.

3.03 HYDROSTATIC TESTS

A. Shell:
   1. Prior to shipment, subject equipment and vessels to water fill leak test to verify shell integrity.
   2. Complete condenser, including exhaust expansion joint, shall be tested at job site at conclusion of installation.
   3. No leakage is acceptable through pressure boundary wall or assembly joints.
   4. Cribbing shall not be required to perform hydrostatic leak test.

B. Water box: Test in accordance with HEI Standard for Steam Surface Condensers.

END OF SECTION

1) R. Hernandez
2) J. Solan
1.01 SECTION INCLUDES

A. Design, manufacture, furnish, and deliver one (1) field-erected air cooled condenser (ACC) and auxiliary equipment, instruments, and safety devices for parallel operation in conjunction with a heat recovery surface condenser, for use in the UAF Combined Heat and Power Plant as described in Section 01 10 00.

B. The work shall include, but not be limited to:
   1. Steam ducting between the steam turbine exhaust flange and the ACC.
   2. Two (2) drain pumps for steam ducting to transfer drains to the condensate drains tank.
   3. Finned tube bundles with steam distribution manifolds and condensate collection manifolds, non-condensable gas removal piping to the hogging and vacuum-holding system, and condensate drain piping and pipe supports to the condenser hotwell.
   4. Air moving system including motors, fans, gearboxes, couplings, fan guards, bells, fan rings and necessary vibration monitoring and auxiliary equipment.
   5. Variable frequency drives (VFD) specifically designed/chosen to operate main air moving system fans. Acceptable drive manufacturers are identified in Section 01 63 00.
   6. Monorails, electric hoist(s), and lifting devices required to remove and maintain air moving system.
   7. Vacuum pumps to hold ACC vacuum.
   8. Complete steam hogger with silencer, to establish ACC vacuum.
   9. Galvanized steel structure to support and anchor the ACC, fan deck and A-frames including maintenance platforms, access stairways, escape ladder, steam ducting, auxiliary equipment, and supplied piping.
   10. Necessary instruments and control devices.
   11. High pressure water washing system for exterior of fin tubes.
   12. Freeze protection by means of steam sectionalizing valve(s) on manifold(s), upper and lower louvers, and any other means, as required, for part load operation and start up at extreme ambient low temperatures (see Data Sheet for design outdoor air temperature).

1.02 WORK BY OTHERS

A. Receiving, unloading, inspection for shipping damage, piece count, and temporary storage of Equipment at site.

B. Site grading.

C. Foundations and anchor bolts.

D. Labor, equipment and tools for erection of complete assembly.

E. External electrical connections, motor starters and motor controls.

F. Plant distributed control system, programming, and I/O wiring.

G. Condensate drain piping between Terminal Points of the ACC and condenser. Reference Section 01 18 00 for Terminal Points.

H. Condensate forwarding pumps.

I. Lightning protection, grounding grid, and grounding system.

1.03 PERFORMANCE REQUIREMENTS

A. The design turbine backpressure is as indicated in Section 00 43 33.

B. ACC will be located outdoors and will be foundation supported. Auxiliary equipment, such as vacuum pumps, SJAE, hogger, and water wash skid, will be located indoors. Auxiliary equipment shall be fully drainable.
C. The control logic should be designed to maintain the backpressure by optimizing the fan speed for the ambient conditions and the steam turbine exhaust energy. The control logic shall also automatically protect the system from freezing by varying fan speed, isolating cells, and/or closing louvers.

1.04 QUALITY ASSURANCE

A. The ACC and all accessories shall meet the performance requirements in this Specification and Contract Documents. It shall also comply with all applicable codes, laws, rules, guides and regulations as applicable.

B. Seller's experience: Proposed condenser shall be a regularly catalogued product of air cooled condenser manufacturer.

C. Acceptable experience is further defined as having proven performance with the fin tube and heat exchanger bundle design, and the mechanical and manufacturing design and process.

1.05 DELIVERY, STORAGE AND HANDLING

A. Piping and other openings shall be plugged or capped to prevent entrance of foreign material.

B. Thoroughly coat exposed machined surfaces with rust preventative coating.

C. Equipment shall be properly covered, skidded, and crated to withstand shipping via an oceangoing vessel and the normal shocks and vibration associated with the shipment and handling of large equipment.

1.06 GUARANTEES

A. Reference Section 01 86 37 Condensing System Performance Requirements.

B. Performance testing will be performed prior to commercial operation. Compliance with the above performance guarantees may be determined by tests performed within 12 months after commercial operation has commenced.

PART 2 PRODUCTS

2.01 AIR COOLED CONDENSER

A. Scope of supply

1. Steam ducting between the steam turbine exhaust flange and the ACC, including required expansion joints, turning vanes, guides, anchors, hangers, other support structures, rupture disc assembly(s), drain pot(s) (if required), manways, and other connections.

2. Two (2) 100-percent-capacity drain pumps for steam ducting (if required by the presence of a drain pot), including instruments, piping, pipe supports, and valves required to transfer drains to the condensate drains tank.

3. Finned tube bundles with steam distribution manifolds and condensate collection manifolds, condensate drain piping and pipe supports to the condenser hotwell as well as supports by the Buyer.

4. Air moving system including motors, fans, gearboxes, couplings, fan guards, bells, fan rings and necessary vibration monitoring and auxiliary equipment.

5. Monorails, electric hoist(s), and lifting devices required to remove and maintain air moving system.

6. Liquid ring vacuum pump skid for air removal with silencers. Vacuum pump skid will hold vacuum during operation when the SJAE skid is not in use.

7. Steam Jet Air Ejector (SJAE) skid for air removal. SJAE skid will hold vacuum during operation when the vacuum pump skid is not in use.

8. Steam jet ejector hogging skid for air removal with silencer.

9. Internal partition walls, access doors, and windwall siding material, including windwall steel support framing.

10. Galvanized steel structure to support and anchor the ACC, fan deck and A-frames including maintenance platforms, access stairways, escape ladder, steam ducting, auxiliary equipment, and supplied piping. Perimeter walkways and catwalks between A-frames should also be included.
11. Anchor bolt diameter and material requirements.
12. Fasteners (bolts, nuts, washers, screws, pins, etc.) and gaskets required for assembly of materials furnished.
13. Interconnecting piping and supports within the ACC footprint.
14. Necessary instruments and control devices, including sensors, transmitters, switches, indicators, flow elements, thermowells, control valves, and pressure safety devices, as required for condenser control, equipment protection, freeze protection, and operation.
15. Special installation and maintenance accessories and tools, including lifting beams, if required, to install and remove the fin tube bundle.
16. Steam duct, risers, manifolds, tanks, piping and supports to be primer-coated.
17. Commissioning spares.
18. Protective coverings and preparation for shipping.
19. Packing, loading, and transportation.
20. Factory testing.
21. Documentation, procedures, and other information.
22. Temporary blanking plates for each ACC row (street), to leak test the ACC after erection.
23. Field service to support startup, operator and maintenance training, commissioning, and field performance testing.
24. Complete system logic specification in narrative form for incorporation into plant distributed control system (DCS).
25. High pressure water washing system for exterior of fin tubes, including rolling spray manifolds, hoses, valves, piping, fittings, and high-pressure pump. Washing system shall be capable of washing either side of the ACC without the need to move the carriage to the other side.
26. Complete set of spare rupture discs, two vibration switches, and two gearbox oil level pressure switches (for commissioning purposes).
27. Noise attenuation devices, as required.
28. Freeze protection by means of steam sectionalizing valve(s) on manifold(s), louvers, or any other means, as required, for part load operation and start up in very cold winter conditions. Purchaser shall provide thermo-acoustic insulation and/or heat tracing as may be required.

B. Condenser must be designed to operate continuously, 24 hours a day, seven (7) days a week. The condenser must be designed to operate with an average minimum equivalent capacity of 98 percent, and an average availability of 99 percent (annual).

C. Configuration: Forced draft.

D. Maximum allowable air cooled condenser dimensions:
   1. Width: Per site layout drawing included in Appendix A.
   2. Length: 250 feet.

2.02 FIN TUBE HEAT EXCHANGER BUNDLES

A. Provide condenser tube bundles consisting of finned tubes and headers arranged to distribute steam, remove air, and to provide sufficient drainage for freeze protection in a manner that meets the performance requirements.

B. Mount tube bundles in an A-frame arrangement to meet plot area requirements.

C. Steam and drain headers shall be of all-welded construction. Gasketed joints and threaded plugs are not acceptable. Design tube bundles to allow thermal expansion of tubes and access to tube joints for maintenance.

D. Fin tubes shall be constructed of carbon steel. Guarantee the proper adhesion of the fins to the tubes.

E. Fin tube shall be protected against atmospheric corrosion. Uncoated tubes are not allowed. The following fin tube technologies are accepted:
   1. Aluminum fins brazed on flat elongated aluminum cladded carbon steel tubes.
F. Remove all internal and external mill scale and coatings before welding or brazing. Internally flush and rinse brazed tube bundles to remove residual fluoride residues from the brazing process. Protect internal surfaces for ocean shipping and storing.

G. Fins shall be capable of withstanding, without damage or deformation, a direct water jet spray at a pressure of 700 psig at a distance of 12 inches, for cleaning purposes and impact of hail up to 1.25 inches in diameter.

H. Tubes shall be elliptical or oval.

I. Fin pitch shall not exceed 11 fins per inch.

J. Fin tubes shall be of single row design to allow for efficient and easy cleaning. Tubes shall be of a flattened tube section to allow for effective heat transfer and low air pressure drop.

K. Provide rigid tube bundles designed to be self-supporting and to be handled as a complete package. Include provisions for thermal expansion of the tube bundles.

L. Design the supports between tubes to ensure that the finned tubes do not have aerodynamic movement and to transmit their weight to the frame structure. Design the support system to take into account the thermal expansion of the pipes and tubes.

M. Design tubes such that individual tube removal and replacement is possible during operation without compromising structural integrity.

N. Each fin tube bundle must be leak tested prior to shipping. The leak test must be an air pressure or vacuum test in accordance with manufacturer standards. Test procedures must be submitted for review.

2.03 TUBE CLEANING SYSTEM

A. Furnish Seller’s standard semi-automatic tube cleaning system, including required equipment downstream of Buyer’s potable water system. The cleaning system shall be adequate to clean tubes to the guaranteed performance.

B. Provide tube cleaning system capable, at a minimum, of automatically cleaning one-third (1/3) of the tube bundle at a time.

C. Provide necessary hoses, couplings, dollies, etc., to allow the tube cleaning system to move between rows.

D. Design the tube cleaning system to be permanently mounted or stored under the ACC.

E. Design the tube cleaning system to operate with demineralized water supplied at 40-80 psig.

F. Provide tube cleaning system water holding tank. Tank shall be mounted remote from ACC, indoors.

G. Provide valved drain connections to drain the water wash permanent piping and pump.

2.04 FANS

A. Design fans to operate continuously, free from excess vibration, and with provisions to avoid air recirculation under normal operating conditions and the specified service conditions.

B. Provide axial flow fans designed and constructed to permit ease of inspection and maintenance and free from obstructions. Fan blades shall be fiberglass-reinforced plastic or extruded aluminum. Blades shall be axial flow and aerodynamically designed.

C. Establish clearance between the fan blades and the fan ring in accordance with the fan manufacturer’s requirements.
D. Fans shall have manually adjustable pitch and be attached to a common hub. Fan hubs shall be galvanized or epoxy-coated carbon steel. Statically and dynamically balance fan hubs and static-moment balance fan blades before shipment so that any set of blades will fit any hub without rebalancing. Permanently mark all parts for easy reassembly at the site.

E. To maximize fan performance, supply fan rings with inlet bells made of fiberglass or polypropylene segments. Provide sufficient tip clearance between fan blades and fan ring to avoid any rubbing but to not exceed the fan manufacturer’s recommendation.

F. Provide fan motors located in the air removal modules.

G. Ensure that the natural frequency of the structure is not within 20% (above or below) of the fan blade pass frequency across the entire operating speed range. Verify this before the structure is fabricated.

2.05 MOTORS

A. Refer to Section 26 05 03 Small and Medium 3-Phase Motors for requirements.

2.06 VIBRATION SWITCHES

A. The vibration switch shall be capable of providing dual switch levels, providing Alert and Shutdown signals. Both sensor outputs will be routed to DCS by Others.

2.07 GEARBOXES

A. Provide each fan with a gearbox designed especially for the intended continuous service. Equip each gearbox with heat-traced helical gears and anti-friction bearings for heavy-duty service. Design gearboxes to rotate in either direction and to absorb the resulting thrust. The AGMA service factor shall be 2.0 minimum.

B. Design the gearbox in accordance with Cooling Tower Institute (CTI) Bulletin Standard 111, except that the gears and bearings shall be Class B with a minimum lifetime of 100,000 hours.

C. Equip the gearboxes with a forced-flow lubricating system and, if required to implement manufacturer’s warranty, electric oil pumps.

D. Provide each gearbox with the means to fill, indicate level of, drain, and sample the lubricating oil. Provide easy access from the permanent fan drive platform. If necessary, provide each gearbox with an air vent for filling.

E. If gearbox has pressurized oil delivery system, provide connection, isolation valve, and 4-20ma transmitter for oil pressure. If gear box does not have pressurized oil delivery system, provide oil level switch at low level.

F. Equip each gearbox with a magnetic drain plug to collect metallic particles that may be present in the lubricating oil.

G. Provide the input shaft end with flexible-disc or elastomeric couplings. Design the coupling between the gearbox and the electric motor to be capable of withstanding both angular and parallel misalignment.

H. Shrink fits (i.e., using an open-flame torch) are not acceptable for gearbox assembly without Buyer written approval.

I. Do not use a roller or ball bearing to accept any thrust force in addition to radial force without written Buyer permission. If this design is used, provide a remote method of determining gearbox lube oil temperature while operating.

J. Bearings shall have an L-10 life of at least 50,000 hours.
K. Provide smooth mounting surface for standard accelerometer vibration sensor mounting in both X (horizontal) and Y (vertical) planes.

2.08 MAIN STEAM DUCT

A. Design and furnish a steam duct of welded construction from the turbine exhaust connection to the ACC, including the expansion joint at the turbine interface.

B. Slope horizontal sections of the steam duct away from the steam turbine exhaust (drain away from turbine).

C. Provide a low point drain pot to remove condensate from the exhaust duct. A drain pot is not necessary if the branch duct to the surface condenser is configured such that water in the exhaust duct will naturally drain to the surface condenser hotwell.

D. Slope horizontal sections of the steam duct toward the steam duct drain pot at a minimum of ¼-inch per 10-feet.

E. As required, provide reinforcement plates around steam duct penetrations.

F. As necessary, provide reinforcement plates and support plates on the steam duct for attachment of Buyer’s supports for piping and cables routed between the ACC and Buyer’s steam turbine building.

G. Provide butt- or socket-welded connections except where bolted connections are required for maintenance.

H. Provide minimum 24 in. diameter hinged access manways in steam duct and distribution headers for internal inspection. Provide a minimum of two manways (one at each end) in the horizontal run of the steam duct between the steam turbine and the ACC.

2.09 REFLUX WARM-UP SYSTEM (IF REQUIRED)

A. Warm-up system will send plant low pressure steam to the condensate headers to preheat the tube bundles prior to turbine rolloff, cold weather only.

B. Steam will be supplied from the plant low pressure steam header.

2.10 DRAIN POT PUMPS (IF REQUIRED)

A. Mount pumps on a common base.

B. Provide two (2) 100 percent capacity pumps suitable for the service conditions and sized to collect condensate from the low point drain pot during both startup and normal operation. Return condensate to the condenser hotwell.

C. Provide an isolation valve and a startup basket strainer in each pump suction line. Provide a spool or spacer plate to replace the startup strainer during normal system operation. Provide a “non-slam” non-return valve and a manual isolation valve in each pump discharge line. The strainers shall be removable without breaking vacuum.

D. Furnish pumps with casing vents with plugs.

E. Design pumps to operate satisfactorily when delivering varying quantities of fluid up to the maximum pump output. Size pump motors so that the selected pump impeller shall not overload the motor at any point on the pump head capacity curve.

F. Generally size pumps for maximum efficiency at the normal operating point. Provide pumps that remain free from excessive vibration throughout the operating range.
G. Size pumps furnished for each application to accept an impeller at least 1/8 inch larger in diameter than the impeller specified without having to change the pump casing.

H. Design horizontal end suction pumps to allow the impeller to be withdrawn from the motor end without disturbing the piping or motor.

I. Where necessary, fit vent and drain valves at suitable points on the pump casing and pipe to floor drains. Design horizontal split-case pumps to allow the removable half-casing and impeller to be withdrawn without disturbing any of the process piping, valves, or motor.

J. As determined by the application, provide pumps with either packing or mechanical seals. Arrange pumps that have mechanical seals to facilitate removing the seals. Specify shaft flingers to prevent packing gland leakage water from entering the bearing housings.

K. Provide bearings with ample surface area. For pumps larger than 100 Hp, provide journal bearings, split for ease of maintenance. Arrange bearings to facilitate removing the pump impeller for repairs.

L. For ball or roller bearings, fit the inner race directly onto the shaft and locate it by a machined shoulder on the shaft. Securely connect intermediate shaft bearings of vertically suspended pumps to the main pump support tube.

M. For bearings requiring cooling water, provide the necessary pipe work, valves, and strainers. Vertical-shaft freshwater or condensate pump bearings situated below water level shall be lubricated by the water being pumped.

N. Provide guards for couplings and any intermediate shafting.

O. Provide bedplates of ample proportions and stiffness to withstand the loads likely to be experienced in shipment and service.

P. Supply pumps used in vacuum service with water seals.

2.11 PIPING AND VALVES

A. Provide the following:
   1. Condensate collection piping within the ACC A-frame envelope, terminating at a single connection point, as noted in Section 01 18 00 Terminal Points.
   2. Air removal piping within the ACC A-frame envelope, terminating at a single connection point, as noted in Section 01 18 00 Terminal Points.
   3. Water wash tubing and piping from the pump to the outlets at the fan deck.

B. Furnish and install piping, valves, and associated supports in accordance with ASME B31.1. Use welded construction for pressure boundaries to minimize potential for air inleakage. Design branch connection details in accordance with manufacturer's standards and ASME B31.1.

C. All piping material shall be ASTM A-106, Grade B, or ASTM A-53, Grade B, carbon steel with exterior primer coating. For exterior piping, use carbon steel materials suitable for temperatures below -60F; such as ASTM A-333 Gr. B.

D. Equip valves exposed to condenser vacuum with special packing and backseats for vacuum service. Furnish valve stems with lantern ring and leakoff connection (plugged) for future water seal.

E. Where practical, arrange valves for convenient access and operation from grade or platforms. Where this is not possible, provide valves with extension stems or chain operators.

F. Provide high point vents and low point drains. Conform design to the requirements of manufacturer's standards.
G. All materials used in the construction of pipe supports, guides, restraints, and anchors shall be in accordance with ASME B31.1. Materials shall be compatible with the piping materials.

H. Consider the most severe conditions of coincident pressure, weight, temperature, and any other fluid dynamic events, and any other applicable loadings, in the design of pipe supports. In addition to the above loading conditions, design piping routed outside and above ground for wind and snow loads (as applicable).

I. Design shear lugs so that half of the shear lugs resisting the load support the total load.

J. Design structural and miscellaneous steel in accordance with AISC standards and specifications.

K. Identify any insulation and heat-tracing requirements on the P&ID.

L. Supply piping in random lengths, with field trim, with one fitting welded on one end.

2.12 MAIN CONDENSATE

A. Condensate from the ACC shall be directed to the condenser hotwell.

B. Deaeration of the condensate is not required.

2.13 VACUUM PUMPS

A. The pumps shall be designed for continuous service when operating under all service conditions, flow capacities, and pressures as depicted in section 00 43 33.

B. The pumps shall be sized to hold vacuum on the condenser under all normal operating conditions.

C. Seller shall furnish a 100% capacity vacuum pump. Vacuum pump shall be designed for 100% air removal capacity. The pump supplied shall be a positive displacement, non-pulsating, liquid ring, rotary vacuum pump with a seal water heat exchanger and separator.

D. The pump shall be driven by a low-speed motor without the use of speed reducers.

E. All pump connections shall be flanged and shall be located above the base plate. The pump must be complete with a structural steel base plate to accommodate pump, motor, and accessories.

F. The pump shall have a gear type flexible coupling and guard between the pump and motor providing access to bearings and seals without moving either the pump or motor which spare parts are available.

G. Pump components that are subject to wear shall be readily replaceable with minimum disturbance to connection piping, drives, etc.

H. Each pump shall be furnished complete with the necessary valves, controls, wiring, and accessories for automatic operation.

I. The pump controls shall operate on 120 volt AC power.

J. All electrical components shall be housed in NEMA 4 weather-proof and watertight enclosures. Enclosures shall have removable covers to provide easy access to connection points and to facilitate adjustments, inspections, and replacements.

K. Each pump shall be furnished with a plate and frame seal water heat exchanger fabricated in accordance with ASME Section VIII. The heat exchanger shall have a maximum design approach temperature of 2.5°F.

L. The pressure drop across the heat exchanger shall be a maximum of 50% of the total pressure drop across the main condenser.
M. Each pump shall be capable of maintaining its design capacity at all ranges of seal water inlet temperatures for the design heat duty.

N. Standard conditions for determining vacuum pump scfm capacity shall be 14.7 psia at 60°F in accordance with HEI standards.

O. The Vendor shall design and furnish pumps suitable for operation over the entire range of expected condenser operation without cavitation.

P. Pumps with cavitation protection shall have a maximum impeller tip speed of 75 feet/second. The Vendor must provide documented proof that the cavitation protection method installed on the pump serves the intended purpose and will not limit condenser pressure or pump capacity.

Q. Pumps without cavitation protection shall have a maximum pump rotational speed of 1200 rpm with a maximum impeller tip speed of 85 feet/second.

2.14 STEAM JET AIR EJECTOR

A. Provide a 100% capacity two-stage, steam jet holding ejector(s), (hogging skid may be packaged with holding skid, if applicable).

B. Provide a silencer to be installed in Seller-furnished exhaust piping to limit noise, as required.

C. A single 100% capacity inter/after condenser must also be provided, allowing simultaneous operation of both ejector trains. The ejector system must be designed to provide 100% rated ejection capacity throughout the range of operating suction pressures.

D. C. Cooling water supply to the inter/after condenser of the holding ejectors will be condensate forwarded by the condensate pumps. Condenser waterside design pressure must be 500 psig minimum. Maximum waterside pressure drop must be less than 10 psi at 100% condensate flow.

E. Motive steam for the SJAE will be from the plant auxiliary steam system at the temperature and pressure defined in Section 00 43 33.

F. Provide necessary piping, valves, fittings, and instruments for a complete skid assembly.

G. Design and construct the holding ejector in accordance with applicable HEI Standards for Steam Surface Condensers and Air Cooled Condensers.

2.15 STEAM HOGGING EJECTOR

A. Provide a single-stage, steam jet hogging ejector(s) with no after-cooler, that exhausts to atmosphere (hogging skid may be packaged with holding skid, if applicable).

B. Provide a silencer to be installed in Seller-furnished exhaust piping to limit noise, as required.

C. Motive steam for the SJAE will be from the plant auxiliary steam system at the temperature and pressure defined in Section 00 43 33.

D. Provide necessary piping, valves, fittings, and instruments for a complete skid assembly.

E. Mount the hogging ejector and associated components on a steel base and shop-assemble to maximum extent possible.

F. Design and construct the hogging ejector in accordance with applicable HEI Standards for Steam Surface Condensers and Air Cooled Condensers.

G. Provide a motor-operated air inlet isolation valve on the hogging ejector.
H. Capacity must be sufficient to reduce pressure in the entire air cooled condensing system and turbine from atmospheric pressure to 10 inches HgA in less than 30 minutes.

2.16 WINDWALL AND CLADDING

A. Furnish a complete windwall enclosure around the perimeter of the ACC. As a minimum, extend the windwall from the fan platform level upward to the top of the fin tube bundles.

B. Base windwall requirements on design and site related factors (minimum ambient temperature, wind speed, prevailing direction, condensate temperature and warm air recirculation potential).

C. Fabricate the windwall of un-insulated, corrugated, galvanized steel panels with factory-applied paint finish (color shall match sample provided by Buyer) secured by exposed stainless steel fasteners. Provide flashing and sealing materials for fascia, base, corners, and around all wall penetrations and openings. Flashing material and finish shall be same as specified for wall panels.

D. Supply the windwall siding and primed support structure per Seller's standard design. Make all attempts to match standard siding shape and finish used throughout the balance of the plant. Provide windwall girt system in accordance with Seller's standard design and using steel shapes Seller normally supplies.

E. Make structural provisions for attaching girts to the ACC structure to transfer all loads from the siding (cladding) system to the structure. Design each siding (cladding) and girt system member to withstand stresses resulting from combinations of loads producing the maximum stresses in that member as indicated in the governing design code.

2.17 STAIRWAYS, LADDERS, WALKWAYS, AND PLATFORMS

A. Provide hot-dip galvanized steel platforming (open grating or Buyer prior-approved alternate), ladders, stairs, treads, cages, handrails, etc., located to permit ready access to all parts of the ACC, steam duct manways, and auxiliary equipment that may require operator attention during operation and to permit ease of maintenance when the ACC is out of service for repairs.

B. Provide one stair tower, located on the north end of the ACC, including handrails, toe kicks, landings, and other required accessories for a complete stair system. Stairs shall provide access to grade and all platform levels.

C. Supply a single caged ladder central to the opposite side wall (south-side). Ladder shall provide access to the fan platforms from grade.

D. Design the fan platform to provide easy access to and support of the mechanical equipment, equip the platform with handrails, and provide a walkway over the entire length.

E. Provide a walkway around the entire perimeter of the ACC at the fan platform level.

F. Provide walkways to give obstacle-free access to all operating points and manways.

G. Provide catwalks between each row of adjacent A-frame sections of the ACC. Catwalks shall have a minimum unobstructed width of 18 inches and a minimum free overhead space of 7 feet.

H. Both the walkways and stairways shall have a minimum unobstructed width of 36 inches and a free overhead space of at least 7 feet.

I. Equip all stairways, catwalks, walkways, and platforms with kickplates and with handrails that include an intermediate pipe and baseplate.

J. Provide platforms for the steam duct rupture disc and each steam duct manway. As a minimum, platforms shall be 3 ft x 3 ft. Provide permanent access to all platforms, except the steam duct rupture disc and the manways in the steam distribution headers.
K. Provide adequate space for safe placement of and access to a moveable/temporary ladder on each exterior side face of each row of tube bundles for access and inspection and for access to the platform at the steam duct rupture disc and the manways on the steam distribution headers without sectioning valves.

L. Provide moveable/temporary ladder(s) for access to tube bundles, rupture disc platform and the manways in the steam distribution headers without sectioning valves.

2.18 MAINTENANCE TROLLEY BEAMS AND HOIST

A. Furnish monorail beams for each condenser row (street) extending the entire length of the street/row. To facilitate removing fan motor and gearboxes and lowering them to ground level, overhang the beams at one end of the platform or provide removable sections of walkway.

B. Furnish movable trolley and electric hoist of standard manufacturer’s design for each monorail beam.

C. Provide festooned cable, supported from the monorail, to allow the hoist/trolley to travel the length of the street/row.

D. Design monorail beams and hoist so that it is not necessary to remove partition walls to allow trolley/hoist movement.

2.19 STRUCTURAL

A. The ACC will be supported from grade.

B. The condenser, accessories, and components must be supported on braced structural steel columns designed and fabricated in accordance with the codes, standards, seismic, wind, and snow load conditions in this Specification.

C. Structural Design Criteria
   1. Reference Section 01 83 00 – Structural Performance Requirements for the following design criteria:
      2. Seismic
      3. Wind loads
      4. Snow loads
      5. Other design criteria not related to the local environment

2.20 INSTRUMENTATION AND CONTROLS

A. Design control logic for the ACC, steam duct drain pumps, holding vacuum pumps, holding ejector and hogging ejector. This control logic shall be implemented in Buyer’s DCS to operate automatically over all operating, startup, shutdown, load change, and ambient conditions with steam from the steam turbine and in conjunction with the condenser.

B. Design control logic to also allow manual override to accomplish all automatic functions. Ensure that the functional design of Seller’s control systems does not restrict operation or response or cause dangerous conditions.

C. Design pressure, level, and temperature sensors to be serviced or replaced without removing the ACC from service.

D. Provide necessary field-smart transmitters, sensors, switches, etc., to support the ACC, steam duct drain pumps, and vacuum system. Provide thermocouple or RTD temperature sensors as specified.

E. Provide all final control drives, actuators, positioners, etc., to control the equipment furnished.

F. Provide fan vibration alarm and trip switches, each with two (2) double-pole, double-throw (DPDT) contacts.
G. Provide either gearbox oil flow or pressure switch for each fan drive gearbox and/or its associated lube oil reservoir.

H. Provide local level indicator for each fan drive gearbox and/or its associated lube oil reservoir.

I. If drain pot is provided, provide one (1) level transmitter and four (4) level switches for the steam duct drain pot (“high-high,” “high,” “low,” and “low-low”) with two (2) DPDT contacts suitable for 120 VAC. The steam duct drain pumps will be controlled through the Buyer’s DCS. Provide local pump discharge pressure indicator.

J. Provide temperature elements (RTD’s) in each condensate return header between the reflux bundles and condenser bundles. Provide temperature elements (RTD’s) in the non-condensable outlet header from each reflux cell.

K. Provide two (2) ambient temperature elements (RTD’s), installed in a location to prevent heating effects from exposure to the sun.

L. Provide one (1) duplex RTD at the inlet of the steam duct.

M. Provide two (2) pressure transmitters at the entrance to the steam duct: one (1) 0-30 psia and one (1) 0-5 psia for fan control. Make tube runs short and sloped to the steam duct.

N. Provide a set of instrumentation for each vacuum pump skid for proper equipment operation. Air flow meters shall be sensitive enough to measure the full range of expected air in leakage.

O. Design and furnish all equipment suitable for outdoor service.

P. Provide instruments and instrument connections required to monitor and test performance, except steam flow and quality and total power, which will be measured by Buyer.

Q. Provide isolated digital and isolated 4-20 mA analog signal outputs to Buyer’s DCS.

R. Except when measuring gas or air temperatures at atmospheric pressure, protect temperature elements by thermowells. Equip temperature test points with thermowells and caps or with plugs and chain.

S. Any thermocouples used shall be ANSI dual-element, ungrounded, spring-loaded, Chromel-Constantan. A local temperature transmitter shall be provided for each thermocouple transmitting a 4-20 mA signal.

T. Any RTDs used shall be dual-element, 100 ohm, platinum, three-wire (R100/RO-1.385), ungrounded. The element shall be spring-loaded, mounted in a thermowell, and connected to a cast iron head assembly. A local temperature transmitter shall be provided for each RTD transmitting a 4-20 mA signal.

U. Provide a wind speed, outside air temperature and direction instrument transmitting a 4-20 mA signal.

2.21 ELECTRICAL

A. Refer to Sections 26 05 03 Small and Medium 3-Phase Motors, 26 05 00 Common Work Results for Electrical Packaged Equipment and 26 29 23 Low Voltage Variable Frequency Drives for additional requirements.

2.22 COLD WEATHER OPERATION/FREEZE PROTECTION

A. Freeze protection shall be designed to protect the unit assuming the worst combination of operating conditions provided in Section 00 43 33 – Bidder Data and information. At a minimum the Seller shall use the minimum continuous steam turbine exhaust flow rate at the extreme minimum ambient temperature.

B. The design shall allow sections of the ACC to be isolated for freeze protection during cold weather and low load operation. Provide motor operated upper and lower louvers and motor operated sectionalizing valves for cold weather operation.
C. The ACC shall be designed to allow safe operation at specified minimum steam flow and concurrent minimum ambient temperature.

D. The tubes, headers, drain pots and piping shall be sized and designed to drain freely and completely to prevent damage due to freezing.

E. Seller shall indicate the need to electric heat trace and insulate instrument control or process lines that may freeze during cold weather.

F. Condensate piping shall be, preferably, self-draining into the condenser hotwell. If low points exist, piping shall be electric heat traced and insulated to prevent freeze up in the event of a winter shutdown. Low point drains shall also be provided. The Buyer shall provide insulation and heat tracing.

G. The ACC shall be designed to prevent uneven distribution of steam and cooling air and excessive sub-cooling of the non-condensable gas so that the evacuation system is not overloaded by steam, and to provide freeze protection in the cold climate.

H. Fin tubes must be designed to accommodate freeze/thaw cycles.

I. Freeze protection features included in Seller’s design must be described in detail in the bid package.

2.23 SOUND LEVELS

A. Basis of Design (for inclusion in bid price)
   1. The steady state sound level from the ACC shall not exceed 42 dB(A) when measured at 400 ft. in any direction from the ACC in a free-field environment.

B. Alternate Noise Option #1 (provide optional price adder, if applicable)
   1. The steady state sound level from the ACC shall not exceed 37 dB(A) when measured at 400 ft. in any direction from the ACC in a free-field environment.

C. Alternate Noise Option #2 (provide optional price deduct, if applicable)
   1. The steady state sound level from the ACC shall not exceed 47 dB(A) when measured at 400 ft. in any direction from the ACC in a free-field environment.

D. Additional sound requirements:
   1. Above fan discharge: 77 dB(A).
   2. 5'-0" horizontally from tower: 69 dB(A).
   3. Steam silencer outlets: 85 dB(A) at 3 feet horizontally from silencer.

E. Provide octave band levels for each option. See Section 00 43 33 for data sheet.

PART 3 EXECUTION

3.01 GUARDS AND SAFETY DEVICES

A. Exposed rotating parts of machinery, including couplings, drives, or other extensions, shall be properly protected with OSHA-approved guards.

3.02 FIELD TESTS

A. It shall be the responsibility of Buyer to provide testing as necessary to verify compliance with guaranteed performance. Tests shall be in accordance with ASME PTC 30.1.

B. Buyer shall provide, services of independent testing firm to conduct test and certify results of ACC performance.

C. If guaranteed performance is not achieved in performance tests, Seller shall make necessary changes and adjustments to Equipment at no cost to Buyer and notify Buyer when ready for retesting or supplemental testing.

D. Field testing shall confirm summer capacity at design conditions in section 00 43 33.
3.03 DEFECTIVE EQUIPMENT

A. If Equipment fails to conform to requirements of Contract Documents or to operate satisfactorily, correct such defects promptly at no cost to Buyer.

B. Buyer will have the right to operate unsatisfactory Equipment until it is replaced or corrected, without cost for depreciation, use, or wear.

C. Equipment will be removed from operation for examination, adjustment, alteration, or change only at times approved by Buyer.

END OF SECTION

1) R. Hernandez
2) J. Solan
Air-Cooled Condensing System

Exhibit A

Contents:

<table>
<thead>
<tr>
<th>Dwg. No</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>SK-M-001</td>
<td>Air-Cooled Condenser Equipment Arrangement Sketch</td>
</tr>
</tbody>
</table>
Air-Cooled Condensing System

Exhibit B

Geotechnical Engineering Report
Air-Cooled Condensing System

Exhibit B

Geotechnical Engineering Report

Since 1954.

Submitted To:
Ms. Kari Pile
Design Alaska, Inc.
601 College Road
Fairbanks, Alaska 99701

By:
Shannon & Wilson, Inc.
400 N 34th Street, Suite 100
Seattle, Washington 98103
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>2.0</td>
<td>PROJECT UNDERSTANDING</td>
<td>1</td>
</tr>
<tr>
<td>3.0</td>
<td>FIELD EXPLORATIONS</td>
<td>2</td>
</tr>
<tr>
<td>3.1</td>
<td>Current Subsurface Explorations</td>
<td>2</td>
</tr>
<tr>
<td>3.2</td>
<td>Existing Subsurface Explorations</td>
<td>3</td>
</tr>
<tr>
<td>3.3</td>
<td>Shear Wave Velocity Measurements</td>
<td>3</td>
</tr>
<tr>
<td>4.0</td>
<td>GEOTECHNICAL LABORATORY TESTING</td>
<td>3</td>
</tr>
<tr>
<td>5.0</td>
<td>SITE CONDITIONS</td>
<td>4</td>
</tr>
<tr>
<td>5.1</td>
<td>Geologic Setting</td>
<td>4</td>
</tr>
<tr>
<td>5.2</td>
<td>Seismicity</td>
<td>4</td>
</tr>
<tr>
<td>5.3</td>
<td>Surface Conditions</td>
<td>5</td>
</tr>
<tr>
<td>5.4</td>
<td>Subsurface Conditions</td>
<td>5</td>
</tr>
<tr>
<td>5.4.1</td>
<td>Soil and Rock</td>
<td>5</td>
</tr>
<tr>
<td>5.4.2</td>
<td>Groundwater</td>
<td>6</td>
</tr>
<tr>
<td>5.4.3</td>
<td>Frozen Ground</td>
<td>6</td>
</tr>
<tr>
<td>6.0</td>
<td>EARTHQUAKE HAZARDS ANALYSIS</td>
<td>6</td>
</tr>
<tr>
<td>6.1</td>
<td>Earthquake Ground Motion</td>
<td>7</td>
</tr>
<tr>
<td>6.2</td>
<td>Liquefaction Analyses</td>
<td>7</td>
</tr>
<tr>
<td>6.3</td>
<td>Settlement Analyses</td>
<td>8</td>
</tr>
<tr>
<td>6.4</td>
<td>Soil Strength Reduction During Liquefaction</td>
<td>9</td>
</tr>
<tr>
<td>6.5</td>
<td>Lateral Spreading</td>
<td>9</td>
</tr>
<tr>
<td>6.6</td>
<td>Fault Rupture</td>
<td>9</td>
</tr>
<tr>
<td>7.0</td>
<td>FOUNDATION RECOMMENDATIONS</td>
<td>9</td>
</tr>
<tr>
<td>7.1</td>
<td>Shallow Foundations</td>
<td>10</td>
</tr>
<tr>
<td>7.1.1</td>
<td>Continuous and Spread Footings</td>
<td>11</td>
</tr>
<tr>
<td>7.1.2</td>
<td>Mat Foundations</td>
<td>11</td>
</tr>
<tr>
<td>7.2</td>
<td>Deep Foundations</td>
<td>12</td>
</tr>
</tbody>
</table>
TABLE OF CONTENTS (cont.)

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.2.1</td>
<td>Axial Capacity</td>
<td>12</td>
</tr>
<tr>
<td>7.2.2</td>
<td>Lateral Resistance of Piles</td>
<td>13</td>
</tr>
<tr>
<td>7.2.3</td>
<td>Lateral Resistance of Piles Caps</td>
<td>14</td>
</tr>
<tr>
<td>7.2.4</td>
<td>Pile Installation</td>
<td>14</td>
</tr>
<tr>
<td>7.2.4.1</td>
<td>Pile-Driving Equipment</td>
<td>14</td>
</tr>
<tr>
<td>7.2.4.2</td>
<td>Wave Equation Analysis</td>
<td>15</td>
</tr>
<tr>
<td>7.2.4.3</td>
<td>Monitoring Pile Driving</td>
<td>15</td>
</tr>
<tr>
<td>7.3</td>
<td>Ground Improvement</td>
<td>16</td>
</tr>
<tr>
<td>7.3.1</td>
<td>General</td>
<td>16</td>
</tr>
<tr>
<td>7.3.2</td>
<td>Vibro-compaction</td>
<td>16</td>
</tr>
<tr>
<td>7.3.3</td>
<td>Deep Soil-improvement Site Preparation</td>
<td>17</td>
</tr>
<tr>
<td>7.4</td>
<td>Foundation Recommendations for Structures</td>
<td>18</td>
</tr>
<tr>
<td>7.4.1</td>
<td>Boiler/Turbine and Administrative Building</td>
<td>18</td>
</tr>
<tr>
<td>7.4.2</td>
<td>Stack and Baghouse</td>
<td>18</td>
</tr>
<tr>
<td>7.4.3</td>
<td>Air-cooled Condenser (ACC) Building</td>
<td>19</td>
</tr>
<tr>
<td>7.4.4</td>
<td>Cold Storage Building and Evaporative Cooling Tower</td>
<td>19</td>
</tr>
<tr>
<td>7.4.5</td>
<td>Ash Silo, Conveyor, and Crusher</td>
<td>20</td>
</tr>
<tr>
<td>7.4.6</td>
<td>Elevated Walkway</td>
<td>20</td>
</tr>
<tr>
<td>7.4.7</td>
<td>Thawing Shed, Transfer House, and Coal Unloading Buildings</td>
<td>21</td>
</tr>
<tr>
<td>7.5</td>
<td>Lateral Earth Pressures on Basement Walls</td>
<td>21</td>
</tr>
<tr>
<td>7.6</td>
<td>Subsurface Drainage</td>
<td>22</td>
</tr>
<tr>
<td>8.0</td>
<td>DIRECT-BURY UTILITIES</td>
<td>22</td>
</tr>
<tr>
<td>9.0</td>
<td>PAVEMENT SECTIONS</td>
<td>23</td>
</tr>
<tr>
<td>9.1</td>
<td>Flexible Pavement Design for Driveways and Access Roads</td>
<td>23</td>
</tr>
<tr>
<td>9.2</td>
<td>Parking</td>
<td>24</td>
</tr>
<tr>
<td>9.3</td>
<td>Site Preparation for Pavement Sections</td>
<td>25</td>
</tr>
<tr>
<td>9.4</td>
<td>Frost Transitions</td>
<td>26</td>
</tr>
<tr>
<td>10.0</td>
<td>RAILROAD SPUR</td>
<td>26</td>
</tr>
<tr>
<td>10.1</td>
<td>General</td>
<td>26</td>
</tr>
<tr>
<td>10.2</td>
<td>Site Preparation for Rail Embankments</td>
<td>26</td>
</tr>
<tr>
<td>10.3</td>
<td>Ballast</td>
<td>27</td>
</tr>
<tr>
<td>10.4</td>
<td>Subballast</td>
<td>27</td>
</tr>
<tr>
<td>11.0</td>
<td>MATERIALS</td>
<td>28</td>
</tr>
<tr>
<td>11.1</td>
<td>Structural Fill</td>
<td>28</td>
</tr>
<tr>
<td>11.2</td>
<td>Non-structural Fill</td>
<td>28</td>
</tr>
<tr>
<td>11.3</td>
<td>Bedding</td>
<td>29</td>
</tr>
<tr>
<td>12.0</td>
<td>CONSTRUCTION CONSIDERATIONS</td>
<td>29</td>
</tr>
<tr>
<td>12.1</td>
<td>Site Preparation</td>
<td>29</td>
</tr>
</tbody>
</table>
TABLE OF CONTENTS (cont.)

12.2 Temporary Slopes ....................................................................................................30
12.3 Surface Drainage ......................................................................................................30

13.0 LIMITATIONS ....................................................................................................................31

14.0 REFERENCES .....................................................................................................................32

TABLES

1 Recommended Soil Parameters for Use in LPILE Analysis
2 Recommended P-Multipliers for Group Effects

FIGURES

1 Vicinity Map
2 Site and Exploration Plan
3 Shear and Compression Wave Data, Boring 14-02
4 Shear and Compression Wave Data, Boring 14-03
5 Shear and Compression Wave Data, Boring 14-06
6 Estimated Depth to Bedrock
7 Shallow Foundations Recommendations
8 Allowable Bearing Pressure versus Footing Width, Continuous Footing
9 Allowable Bearing Pressure versus Footing Width, Square Footing
10 Estimated Settlement versus Mat Foundation Unfactored Bearing Pressure
11 Estimated Ultimate Axial Capacity, 12-Inch-Diameter, Closed-End Pipe Piles
12 Estimated Ultimate Axial Capacity, 16-Inch-Diameter, Closed-End Pipe Piles
13 Estimated Ultimate Axial Capacity, 20-Inch-Diameter, Closed-End Pipe Piles
14 Estimated Ultimate Axial Capacity, 24-Inch-Diameter, Closed-End Pipe Piles

APPENDICES

A Soil and Rock Classification System and Boring Logs
B Laboratory Test Results
C Site-specific Seismic Hazard Analysis
D Liquefaction Analyses Results
E Important Information About Your Geotechnical/Environmental Report
GEOTECHNICAL ENGINEERING REPORT
UNIVERSITY OF ALASKA FAIRBANKS
HEAT AND POWER PLANT REPLACEMENT PROJECT
FAIRBANKS, ALASKA

1.0 INTRODUCTION

This report presents the results of our subsurface explorations, field and laboratory testing, and our geotechnical engineering studies for the proposed Heat and Power Plant Replacement project (Project) on the University of Alaska Fairbanks (UAF) campus. Our services included exploring subsurface conditions, performing shear wave velocity and geotechnical laboratory tests, performing engineering analyses, and providing geotechnical design recommendations for the Project. Our services were provided in accordance with our proposal dated April 1, 2014.

2.0 PROJECT UNDERSTANDING

The Project site is located on the UAF campus as shown in Figure 1. We understand the replacement heat and power plant complex site is approximately 6 acres in size, immediately southeast of the existing plant, in an area occupied by a greenhouse and other small structures and a few stands of brush and trees at the time of our fieldwork.

We explored the proposed area with seven borings in 2012 and provided a geotechnical findings report summarizing the subsurface conditions encountered and concept-level discussion regarding foundation options, site development concerns, and potential site preparation requirements.

We understand the complex includes several facilities as outlined in plan sheet C208A. Details regarding the structure were provided in a March 26, 2014, e-mail. The proposed new facilities and our understanding of the facilities are summarized below:

- **Boiler/Turbine and Administrative Building:** The building complex will be near 300 feet long with a footprint near 30,000 square feet. The boiler portion of the structure will be an approximately 14,800-square-foot, approximately 113-foot-high structure with a proposed basement level near 12 feet below grade. The at-grade turbine area of the building is approximately 6,000 square feet. The administration area may include up to 3,500 square feet of office, control room, and supporting space. The structure also includes a near 5,000-square-foot baghouse and a stack.

- **Air-cooled Condenser (ACC):** This building will be a detached 3,800-square-foot structure located adjacent to and southeast of the Boiler/Turbine and Administrative Building.
Cold Storage Building and Evaporative Cooling Tower: A near 8,100-square-foot structure located east of the Boiler/Turbine and Administrative Building.

Ash Silo and Ash Loading Building: The detached ash-handling structure is approximately 1,700 square feet, located south of and connected to the Boiler/Turbine and Administrative Building with a conveyor.

Material Handling Building (Coal Unloading and Crusher Building): More than 12,000 square feet of structure that includes a 200-foot-long railcar thawing shed, coal crushers, and transfer conveyors all in a continuously heated structure.

Elevated Walkway: A proposed near 350-foot-long elevated walkway north of the Boiler/Turbine and Administrative Building, which will connect the new and existing plant piping, electrical, and communication lines and provide a walkway.

New Rail and Switches: Near 1,500 lineal feet of new rail track and several new switches. A portion of the new rail will pass through the Material Handling Building.

Driveways and Parking areas: Site development for the proposed facilities includes driveways and several parking areas.

3.0 FIELD EXPLORATIONS

3.1 Current Subsurface Explorations

We subcontracted drilling to Homestead Drilling Company (Homestead) of Fairbanks, Alaska. Homestead drilled fourteen exploratory borings, designated borings 14-01 through 14-14, ranging from 16.5 to 102 feet below the ground surface (bgs). The approximate boring locations are shown in Figure 2. Drilling occurred June 6 through 19, 2014, using a Mobile B-61 truck-mounted drill rig equipped with 8-inch-outside diameter (O.D.) hollow-stem augers. Peter Grey, a geologist with our firm, observed drilling operations and logged soil conditions. Logs of the conditions encountered in the borings are provided in Appendix A. As the borings progressed, we obtained split-spoon samples at 2½-foot intervals from 2½ to 20 feet bgs, at 5-foot intervals thereafter to 50 feet, and then at 10-foot intervals below 50 feet.

Samples were obtained by driving a 2½-inch-inside diameter (I.D.) split-spoon sampler into the soil at the base of the augers. The sampler was driven using a 340-pound automatic hammer falling 30 inches onto the drill rods, referred to in this report as a large penetration test (LPT). The blows required to drive each 18-inch sample were recorded. The number of blows required to advance the sampler the final 12 inches of the 18-inch sample is termed penetration resistance, a measure of the relative consistency of unfrozen, fine-grained soils and relative density of unfrozen, granular soils. Soil samples recovered using these techniques were classified in the field, sealed in airtight containers, and returned to our laboratory for testing.
In borings 14-02, 14-03, 14-05, and 14-06 bedrock samples were obtained by driving a 2-inch-I.D. diamond-tipped core barrel. Thirty-seven feet of bedrock core sample was obtained. The core samples were logged by our geologist, labeled, photographed, and placed in core boxes for transportation to our laboratory.

3.2 Existing Subsurface Explorations

We explored the project site with seven borings in 2012. The approximate locations of our 2012 explorations are shown in Figure 2. The boring logs for these explorations are presented in our preliminary geotechnical report (Shannon & Wilson, Inc. [Shannon & Wilson], 2012).

3.3 Shear Wave Velocity Measurements

Shannon & Wilson conducted shear wave (S-wave) velocity testing at the project site in three borings designated borings 14-02, 14-03, and 14-06 to depths of 80, 80, and 100 feet, respectively. Testing was accomplished by initiating an S-wave in two directions by striking a sledgehammer on opposing ends of a weighted wooden beam, fitted with metal end caps. The generated S-waves were recorded on the transverse channel of a BHG-3 borehole geophone connected to a Geometrics Geode 24-channel seismograph controlled by a field laptop running the Single Geode Operating Software. Compression waves (P-waves) were collected by striking a metal plate with a sledgehammer and utilizing the vertical geophone of the BHG-3. Downhole S-wave and P-wave velocities were generally collected at 6.6-foot (2-meter) intervals from the bottom of the boring to approximately 23 feet (7 meters) bgs and at 3.3-foot (1-meter) intervals to the ground surface. Figures 3 through 5 present plots of the recorded S- and P-wave travel times, interval velocities, and interpreted layer velocities.

4.0 GEOTECHNICAL LABORATORY TESTING

We performed geotechnical laboratory tests on selected samples retrieved from the borings to evaluate index properties and engineering characteristics of the soil encountered at the site. We reviewed sample field classifications in our laboratory and prepared selected samples for testing. We conducted our laboratory testing in general accordance with ASTM International (ASTM) procedures. Our laboratory testing program consisted of 73 moisture content analyses (ASTM D2216) (ASTM, 2010) and 84 grain size distribution analyses (ASTM D422/C136) (ASTM, 2006, and ASTM 2007). The laboratory test results were incorporated into the boring log soil descriptions included in Appendix A. Moisture contents and percent passing the No. 200 sieve are shown in the boring logs. Appendix B presents the grain size distribution plots.
5.0 SITE CONDITIONS

5.1 Geologic Setting

The Project site is at the boundary between the Yukon-Tanana Uplands and the Tanana Lowlands. The Uplands are composed of weathered schist bedrock hills covered by loess or windblown silt. The silt deposits are generally thinner at higher elevations, while lower slopes may have thicker deposits of reworked silt. The Tanana Lowlands form a large arcuate band between the Alaska Range to the south and the Uplands to the north. The Lowlands consist of vegetated floodplains, low benches, organic-rich swales, and oxbow lakes representing former river channel positions. Soils in the lowlands typically consist of interbedded sands and gravels mantled by silty overbank deposits.

The Fairbanks area lies within a subarctic zone underlain by discontinuous permafrost. Previous studies completed by us and others near the project area have encountered discontinuous permafrost. Historic borehole logs from UAF files show several borings adjacent to the power plant encountering permafrost. However, permafrost was not encountered in the borings drilled for the Project. Permafrost is defined as that part of the earth’s surface in which a temperature below 32 degrees Fahrenheit has existed for two or more years. The maximum depth of permafrost measured in the Fairbanks area exceeds 200 feet. The thickness of the active layer (the near-surface ground which undergoes an annual freeze-thaw cycle) is largely dependent on soil type, ground cover, and snow depth. Frost penetration beneath roads and parking lots commonly exceeds 10 feet.

5.2 Seismicity

The Fairbanks area lies between two right-lateral shear systems: the Denali Fault System approximately 60 miles to 80 miles south of Fairbanks, and the Kaltag and Tintina Fault Systems approximately 80 miles north of Fairbanks. The shear along these systems is believed to be the result of crustal adjustments in the North American Plate due to convergence with the Pacific Plate along the Gulf of Alaska.

Seismicity in the area has historically been concentrated in clusters or bands with a northeast-southwest trend that indicates active faulting, although no faults with Holocene displacement have been recognized in the Fairbanks area (Page and others, 1991). These seismic zones include the Salcha Seismic Zone (SSZ) about 25 miles southeast of Fairbanks, and the Fairbanks Seismic Zone and Minto Flats Seismic Zone about 25 miles northwest of Fairbanks. Page and others (1995) hypothesized these bands delineate the edges of blocks rotating clockwise between two right-lateral shear systems. Outside these northeast-trending linear seismic zones, recorded
seismicity appears diffuse. The earthquakes in the Fairbanks area typically occur at depths of
less than 25 miles.

Within the past century, the Fairbanks area has been subjected to three large earthquakes. On
July 22, 1937, a magnitude 7.3 (Mw) event occurred in the SSZ about 23 miles southeast of Fort
Wainwright. This event, widely felt throughout central Alaska, produced extensive ground
failures in the epicentral area (Page and others, 1995). Two other earthquakes, an October 15,
1947, Mw 7.2 event about 41 miles south-southwest of Fairbanks and an August 27, 1904, Mw
7.3 event about 17 miles southwest, are not correlated with apparent seismic zones. Data from
the 1947 event suggest thrust-faulting, in contrast to the strike-slip faulting suggested in the
Fairbanks area. The epicenter of the 1904 earthquake, predating the College seismograph at the
UAF, is uncertain.

A November 3, 2002, Mw 7.9 event on the Denali Fault approximately 90 miles south of Fort
Wainwright was felt widely throughout central and southern Alaska, and resulted in minor
liquefaction in the Fairbanks area. The peak horizontal ground acceleration of this event
recorded on bedrock at the UAF campus was 0.09g.

5.3 Surface Conditions

The proposed building site, at the time of our fieldwork, consisted of a largely cleared area
approximately 6 acres in size. Some portions of the site had small stands of trees or brush cover.
Several small greenhouse buildings and associated structures also occupied the site. The ground
surface gently slopes from north to south, becoming flatter towards the south.

The proposed site has been developed and much of the surface soils reworked. Some of the
surface soil appears to be material consisting of completely weathered schist bedrock fill.

5.4 Subsurface Conditions

5.4.1 Soil and Rock

The site is mantled with fill, which varies from about 2 to 10 feet thick. In the borings to
the north we encountered greater depths of fill, often 7 or 8 feet, and in the borings to the south
we encountered as little as 2 feet of fill. The fill often consisted of completely weathered schist
(GP-GM, SP-SM, GM, or SM).

Below the fill we encountered loose to medium dense, sandy silts; silty sands; and sands
to depths of 8 to 16 feet. Below these materials, we encountered alluvially deposited, loose to
medium dense, interbedded sands; sands with gravel; and gravels with sand over completely to
highly weathered schist bedrock. We found the bedrock at depths as shallow as 33 feet in boring 14-01 to the north to as deep as 76 feet in boring 14-08 in the south. Figure 4 shows the estimated depth to bedrock. The estimated depth to bedrock was developed using borings completed for this project and data from previous projects.

Surficial soft, compressible, and/or frost-susceptible material depths are presented in Figure 2.

5.4.2 Groundwater

Groundwater levels vary with season and exploration location. Our interpretation of the groundwater depths at the project site is based on groundwater observations during drilling, which are less accurate than groundwater measurements from piezometers. Piezometers were not installed in the borings. We observed groundwater at the time of drilling at depths of 11 to 16 feet bgs. Interpreted depth to groundwater is presented in Figure 2.

5.4.3 Frozen Ground

We observed frozen soil in the seven borings performed in April and May 2012 from about 2.5 up to 7 to 11.5 feet bgs. We observed frozen soil in borings 14-02, 14-03, 14-13, and 14-14, which were performed in June 2014 from the ground surface to about 7 feet bgs.

Because the frozen soil we encountered was relatively shallow and did not extend beyond the expected frost depth, it is our opinion that the frozen soil encountered in the borings is seasonally frozen ground. We did not encounter permafrost in our explorations.

6.0 EARTHQUAKE HAZARDS ANALYSIS

The project is in a seismic area where major earthquakes can and have occurred. Earthquake-induced geologic hazards that may affect a site include landsliding, ground-surface fault rupture, and liquefaction and associated effects (e.g., loss of shear strength, bearing-capacity failures, loss of lateral support, ground oscillation, and lateral spreading). An associated effect of earthquake shaking is densification of the soils and potential settlement of the ground surface.

Due to the presence of loose soils below groundwater, we believe the primary hazard at the site is liquefaction and associated effects. We understand the proposed power plant complex will be designed as an essential facility, which must remain operational and safe to occupy during and after the design seismic event.
In the borings drilled for the project, numerous samples from below the water table had uncorrected penetration resistance values (blow counts) of less than 20; many had blow counts of less than 10. It has been our experience that soils in the Fairbanks area with blow counts as low as these are susceptible to liquefaction and dynamically induced densification if subjected to earthquake ground motions implied by the 2009 International Building Code (IBC).

Densification of granular soils above and below the water table during earthquake shaking could result in significant ground settlement at the site. Associated effects of liquefaction may include a loss of soil-shear strength, potential bearing-capacity failures, and lateral spreading. Our analysis of earthquake ground motions and earthquake-induced geologic hazards that may affect the site are described below.

6.1 Earthquake Ground Motion

We understand that the seismic design for the project will be in accordance with the IBC (International Code Council, 2009). The IBC (2009) references the American Society of Civil Engineers (ASCE) Standard 7-05 (ASCE, 2005). The design ground motion in the IBC is the maximum considered earthquake (MCE), which corresponds to a 2 percent probability of exceedance in 50 years, which corresponds to a 2,475-year return period ground motion.

We performed a site-specific seismic evaluation of the site, including geophysical studies and analyses, to develop seismic response spectra for the site. Based on the calculated average shear wave velocities in the upper 100 feet, the subsurface conditions are Site Class C without regard to liquefaction. The details of our site-specific seismic evaluation and recommended design spectra are provided in Appendix C. The site-specific ground response analyses were performed based on improved soil conditions, i.e., assuming the soil has been densified to mitigate liquefaction. We provide our recommended design spectrum in Appendix C as Figure C-22 for MCE ground motion level.

To estimate the potential for liquefaction, we developed peak ground accelerations (PGAs) in general accordance with the IBC (2009) using the mapped MCE ground motions adjusted for Site Class C soil conditions. We performed the liquefaction potential analyses based on in situ soil conditions using a PGA of 0.35g.

6.2 Liquefaction Analyses

Liquefaction of loose, saturated, cohesionless soils due to seismic loading has been studied over the past 40 years, resulting in methods based on both laboratory and field procedures to evaluate liquefaction potential. The most widely used methods are empirical and based on correlations between Standard Penetration Test (SPT) resistance (N-value), PGA, and earthquake magnitude.
We assumed a magnitude 7.3 for our analyses. We selected the magnitude based on recent earthquakes that have occurred near Fairbanks, as discussed in Section 5.2. The 2002 Denali earthquake was not considered in our selection because it occurred farther away from Fairbanks than other lower-magnitude earthquakes.

We used three empirical procedures to evaluate liquefaction potential at this site:

- Youd and others (2001)
- Cetin and others (2004)
- Idriss and Boulanger (2006)

In these procedures, the N-value (blow count) is correlated to the liquefaction resistance of the soil (expressed as cyclic resistance ratio). The soil resistance is compared to the earthquake-induced loading (expressed as cyclic stress ratio), and a corresponding factor of safety (FS) against liquefaction is calculated.

In accordance with Section C11.8.3 in ASCE 05, we considered the soil to be potentially liquefiable if the calculated FS is less than or equal to 1.0.

The penetration values obtained in the project borings were based on a large-diameter penetration test using a 340-pound hammer. We assumed the LPT blow counts were approximately equivalent to SPT N-values.

Results using the three procedures predict relatively widespread liquefaction in alluvial sand and gravel samples from below the groundwater table to about 40 to 45 feet bgs or the top of bedrock, whichever is shallower. Our liquefaction analyses results are presented in Appendix D. These results are consistent with our preliminary analyses performed in 2012. The primary effects of liquefaction at the site are a reduction in soil-shear strength and dynamic settlement.

### 6.3 Settlement Analyses

An associated effect of earthquake shaking is densification of loose to medium-dense cohesionless soils that undergo liquefaction and potential settlement. We used the relationships by Tokimatsu and Seed (1987) and Ishihara and Yoshimine (1992), relating earthquake ground motion and penetration resistance with volumetric strain, to estimate the potential for free-field ground settlement in the borings we considered in the liquefaction analyses. These relationships are approximate, but reflect the current state of practice.

Using these relationships, in conjunction with the three procedures used to evaluate liquefaction potential at this site, we estimate a range of 6 to 14 inches of free-field settlement at the ground
surface. In our opinion, the ground settlement may not occur uniformly over the project area and could be differential within structure footprints.

6.4 Soil Strength Reduction During Liquefaction

We estimated the reduction in soil-shear strength during liquefaction in borings using relationships by Olson and Stark (2003), Idriss and Boulanger (2007), and Kramer (2008) correlating SPT N-value with apparent shear strengths. Based on the estimated mean of the residual strength from the three methods, we estimate the average residual internal friction angle of soils below the water table during liquefaction could be reduced by about 60 to 70 percent for in situ soil conditions.

6.5 Lateral Spreading

Lateral spreading is a phenomenon that can occur in loose to dense, saturated, granular soils beneath even very gently sloping ground surfaces and on level ground near slopes (i.e., free faces) such as riverbanks or lakes.

Liquefaction in gently sloping ground or ground adjacent to a free face can result in permanent lateral ground displacement in a phenomenon known as lateral spreading. Lateral spreading ground movement can occur toward a free face during or after seismic shaking in saturated, loose to medium dense, granular soil. Because the site topography is generally flat and there is no free face the potential for lateral spreading is low, in our opinion.

6.6 Fault Rupture

We reviewed a geologic map of the area by the State of Alaska Division of Geological and Geophysical Surveys (Public Data File 96-16) to evaluate the proximity of active faults to the project. This map shows no mapped faults displacing Holocene sediments in the area. Seismicity in the Fairbanks area has historically been concentrated in clusters or bands with a northeast-southwest trend that indicates active faulting, although no faults with Holocene displacements have been recognized in the Fairbanks area (Page and others, 1991). We note the relative recent age of the floodplain deposits in the Fairbanks area may limit expression of underlying faults that result in surface-fault rupture during a relatively rare event. In our opinion, the risk for surface-fault rupture at the project site is low.

7.0 FOUNDATION RECOMMENDATIONS

The proposed structures for the Project include essential and non-essential structures. Essential structures for the proposed Project will be designed to protect life safety and remain operational
in the event of the design earthquake. Non-essential structures will be designed to protect life-safety but may not remain operational. We understand that the structures will be designed in accordance with the 2009 IBC (International Code Council, Inc., 2009).

Some of the lightly loaded structures could be supported on shallow foundations. More heavily loaded structures will need to be supported on deep foundations. Because of the potential for liquefaction and the resulting soil strength loss and settlement, ground improvement to mitigate liquefaction will be required for structures supported on shallow foundations. Structures could be supported on deep foundations without mitigating liquefaction. However, liquefaction could result in high downdrag loads and little lateral resistance from the soil during liquefaction. Therefore, we recommend performing ground improvement to mitigate liquefaction for structures supported on deep foundations.

Our explorations indicate the depth to the bottom of silty soils varies across the site and range from approximately 2 to 16 feet bgs in our borings. These surficial silty soils are potentially compressible and frost susceptible, and may contain organics. We recommend removing these soft, compressible, and frost-susceptible soils to reduce the potential for frost heave. Recommendations for site preparation and soil replacement for shallow and deep foundations and ground improvement are presented in the following sections.

We provide recommendations for ground improvement and shallow and deep foundations in the following sections. The foundation types specified for each structure were selected based on the loads provided by Mr. Lance Sulzen of Stanley Consultants, Inc. in an e-mail dated July 23, 2014. At the request of Mr. Kenneth Koch, we provided recommendations for a mat foundation for the Boiler/Turbine and Administrative building.

7.1 Shallow Foundations

Essential and non-essential structures could be supported on shallow foundations provided ground improvement techniques are used to mitigate liquefaction and soft, compressible and/or frost-susceptible soils are excavated and replaced with compacted structural fill. Shallow foundations could consist of continuous and spread footings or mat foundations. Our recommendations in the following paragraphs assume the soft, compressible and/or frost-susceptible soils are removed and replaced with well-compacted structural fill and the underlying sand and gravel is densified to mitigate liquefaction as described in Section 7.3.

Site preparation should include replacing soft, compressible, and/or frost-susceptible materials with a structural fill down to in situ, relatively clean sands and gravels within the limits of the excavation. The base of excavation should extend beyond the edge of footings a minimum
distance equal to the distance from the bottom of footing to the top of in situ soil, as shown in Figure 7. The base of excavation should be free of organic material. Our experience in the area indicates locally deeper deposits of organics and wood debris may require deeper excavations to remove these materials. More detailed site preparation recommendations are provided in Section 12.1.

7.1.1 Continuous and Spread Footings

Gross allowable bearing pressures for continuous and square footings are presented in Figures 8 and 9, respectively. The static allowable bearing pressure can be increased by one-third for seismic conditions. Recommended allowable bearing pressures assume a minimum embedment depth of 2 feet.

Resistance to lateral forces can be provided by passive earth pressures acting against the embedded portion of foundations and frictional resistance against the base of the foundations. Passive resistance should be ignored in the upper 24 inches where not covered by pavement or concrete and should be ignored entirely if a possibility exists that soil providing the resistance could be removed in the future. In our opinion, passive earth pressures in structural fill can be estimated using an equivalent fluid weight of 300 pounds per cubic foot (pcf). This value includes a FS of 1.5.

We recommend a coefficient of friction between cast-in-place concrete and compacted structural fill of 0.4 be used for calculating resistance to sliding at the base of footings and grade beams.

For structures supported on structural fill, we estimate total static settlement will be less than 1 inch, provided the underlying in situ soil is densified as described in Section 7.3 and good construction practices are followed. Differential settlements under static conditions are anticipated to be about three-quarters of the total static settlement. Static settlements will occur as the load is applied to the structure. With ground improvement both above and below groundwater, we estimate potential earthquake-induced ground settlement across the structures would be reduced to less than 2 inches.

7.1.2 Mat Foundations

Figure 10 presents unfactored bearing pressure versus settlement for mat foundations constructed on compacted structural fill and densified in situ soil. We recommend that the base of the mat be embedded a minimum of 2 feet below finished grade to protect the mat from being undermined by surface activities.
The modulus of subgrade reaction ($k_S$) for the mat foundation can be characterized using the following equations:

1. $k_S = p/\delta$ (in units of force per length cubed)
   where:
   - $p =$ applied stress
   - $\delta =$ displacement under $p$

2. $k_S = \left(\frac{0.65}{B}\right) \left(\frac{E}{E_f I_f}\right)^{1/12} \left(\frac{E}{1-\nu^2}\right)$
   where:
   - $B =$ width of footing
   - $E =$ subgrade material Young’s modulus
   - $E_f =$ footing Young’s modulus
   - $I_f =$ footing moment of inertia
   - $E_f I_f =$ footing stiffness
   - $\nu =$ subgrade material Poisson’s Ratio

For mat foundations founded on sandy gravel to gravelly sand (either compacted structural fill or in situ soil densified using vibratory compaction to a medium dense state or denser), we recommend assuming $\nu = 0.3$. For the modulus of subgrade reaction calculation, the elastic modulus of the soil, $E$, will depend on the depth of the mat foundation. If the bottom of the mat foundation is located within the upper 10 feet, we recommend assuming $E = 2,000$ kips per square foot (ksf). If the bottom of the mat foundation is between 10 and 15 feet bgs, we recommend assuming $E = 2,500$ ksf.

### 7.2 Deep Foundations

Structures with loads that cannot be supported on shallow foundations could be supported on driven, closed-end pipe piles penetrating bedrock similar to the piles used to support the diesel-engine generator (DEG) and DEG building at the existing UAF power plant. Our recommended axial and lateral pile capacities are based on the following assumptions:

- Ground improvement is performed as described in Section 7.3.
- Soft compressible and frost-susceptible soils are removed and replaced with compacted structural fill.
- Piles are installed after ground improvement is completed to reduce the potential for downdrag loads that would occur during soil densification.

#### 7.2.1 Axial Capacity

We evaluated the axial capacity of 12-, 16-, 20-, and 24-inch-diameter closed-end driven pipe piles. Our analyses are based on our interpretation of the subsurface conditions, relative
densities of the subsoils as determined by split spoon blow count values, and our experience in similar soil and project conditions. Closed-end, 12.75-inch-diameter piles were used to support the DEG and DEG building for the Clean Coal Demonstration (CCD) project at the existing UAF power plant. We considered the pile driving records and analyses and our experience and observations for the CCD project in our axial pile capacity analyses.

Our estimated axial capacities are presented as a function of depth to bedrock for each diameter pile. Figures 11 through 14 show the estimated ultimate compressive and uplift capacities as a function of depth to bedrock. To obtain allowable capacities, we recommend applying the appropriate FSs provided in Figures 11 through 14. The depth to bedrock varies across the site and increases to the south. The depth to bedrock at specific locations can be estimated using the contours shown in Figure 6; however, localized variations in bedrock depth can occur and should be anticipated.

The piles should be driven into bedrock to achieve the estimated axial capacities. Based on our experience at the DEG building, we anticipate that the piles will need to be driven at least several feet into the schist bedrock to achieve the estimated capacity. However, our experience indicates strength characteristics of the underlying schist bedrock are highly variable and we expect intermittent softer and harder zones within the schist so the actual embedment depth may vary. If the desired capacity is not achieved within the estimated embedment depth, the Contractor should be prepared to increase the pile embedment.

For cost-estimating purposes, we suggest assuming a minimum pile embedment depth of 10 feet into the bedrock. The estimated top of bedrock is shown in Figure 6. Because of the variability of the rock strength, we recommend the minimum embedment of each pile should be determined using the driving criteria developed during driving of the first pile.

To avoid pile-tip damage during driving into bedrock, the piles should be protected with a conical driving point welded to the bottom of the pile and flush with the outside of the pile.

### 7.2.2 Lateral Resistance of Piles

Lateral loads acting on structures from earthquake, wind, and other loadings may be resisted lateral resistance provided by the piles. The computer program LPILEPLUS (Reese and others, 2010) may be used to evaluate the lateral resistance of the piles supporting the structures, to generate P-Y curves (load deflection curves) for the lateral resistance analyses of piles, and to calculate the magnitude of deflection, shear, and moment along the piles. Table 1 provides our recommended soil parameters to input into LPILE PLUS. The soil parameters included in Table 1 should be used for static and seismic analyses provided: (a) the soil is densified sufficiently to
mitigate liquefaction, and (b) near-surface, soft, compressible and frost-susceptible soil is removed and replaced with compacted structural fill.

The recommended soil parameters for use in GROUP analyses for the deep foundations should be adjusted using the P-multipliers summarized in Table 2 to account for group effects. These efficiency factors should be used in lateral resistance analyses of pile groups. Because the IBC does not provide specific guidelines on P-multipliers, the recommended values in Table 2 are based on recommendations presented in the American Society of State Highway and Transportation Officials load and resistance factor design bridge design specifications (AASHTO), 2012.

7.2.3 Lateral Resistance of Piles Caps

Lateral loads acting on structures from earthquake, wind, and other loadings may be resisted by passive-earth pressure against the pile caps/slabs/grade beams and frictional resistance developed between the sides of the pile cap and surrounding soils. Frictional sliding resistance at the base of the pile cap should not be used, in our opinion, because a pile-supported structure may not transmit load directly to the soil beneath pile caps/slabs/grade beams.

Because the foundations will likely be designed to limit movement, full passive resistance will not be mobilized. For a pile cap with ½ inch of movement, we recommend evaluating the passive resistance of pile caps using an ultimate, mobilized passive pressure of 300D pcf, where D is the distance below the top of pile cap. We recommend applying an FS of 1.5 to calculate the allowable passive pressure.

To evaluate sliding along the side of the pile caps, we recommend assuming an at-rest earth pressure equivalent fluid weight of 60D pcf acting on the pile cap sides and a coefficient of friction between the soil and formed concrete pile cap of 0.35.

7.2.4 Pile Installation

7.2.4.1 Pile-Driving Equipment

Fixed-lead pile driving equipment is recommended to drive the steel pipe piles. The use of hanging or swinging leads is not recommended, unless they are constructed so that they can be held in a fixed position during driving operations. Leads should be of sufficient length so that the use of followers will not be necessary. An air-, steam-, or diesel-powered hammer may be used for driving the proposed piles.
7.2.4.2  Wave Equation Analysis

Efficient pile driving can be defined as driving the pile to the desired ultimate capacity (twice the design load) at a reasonable blow count (less than 140 blows per foot) and with driving stresses not exceeding 80 percent of the yield strength of the pile. To establish driving criteria for pile installation, Wave Equation Analyses for Pile driving (WEAP) should be performed using data for the actual hammer/pile combination to be used to install the production piles. WEAP allows evaluation of driving stresses so that an appropriate pile-driving hammer size can be selected to obtain the desired pile capacity with reasonable blow counts and without damaging the piles.

To better evaluate the feasibility of different pile options and their driveability into bedrock, we recommend that a test pile program be developed and performed prior to completing final design. The test pile program would consist of driving different pile types/sizes and performing dynamic testing using a Pile-Driving Analyzer. We also recommend that Case Pile Wave Analysis Program be performed on each test pile.

7.2.4.3  Monitoring Pile Driving

Pile driving should be monitored by taking a continuous driving record of each pile. For this purpose, the Contractor should be required to mark the pile in 1-foot increments. During re-drive, additional 1-inch increments between the 1-foot marks would be required.

The pile-driving record should be complete. The form should have spaces to record hammer stroke (diesel hammers), blows per foot, time, date, reasons for delays, and other pertinent information. The record should include tip elevation, driving criteria, and initials of inspectors making final acceptance of the pile. The pile-driving records should be reviewed on a daily basis. For this purpose, we recommend that an experienced and qualified geotechnical engineer familiar with the subsurface conditions of the project site be assigned to assist in construction monitoring.

It has often been difficult in the past to estimate the energy delivered by diesel hammers. The Saximeter, developed by Pile Dynamic, Inc., can be used to record hammer strokes and provide an estimate of the driving energy of diesel hammers. If the Contractor selects a diesel hammer, we recommend that a Saximeter be used during pile driving.
7.3 Ground Improvement

7.3.1 General

Because of the potential for deep, widespread liquefaction, ground improvement is necessary to reduce the potential for liquefaction-induced strength loss and settlement. Ground improvement techniques fall into three general categories: removal and replacement, densification, and reinforcement. Densification methods are intended to sufficiently compact the soil so that it is no longer liquefiable. Densification can typically be achieved in soils that have less than about 10 to 15 percent fines. For soils where densification sufficient to mitigate liquefaction cannot be achieved, the soil can be reinforced using stiffer elements such as soil-cement columns or panels, stone columns, or structural elements.

Laboratory grain size distribution test results on soil samples retrieved from explorations at the Project site indicate soil below the groundwater consists of sand and gravel with generally less than 10 percent fines content. In our opinion, this soil at the Project site can be densified sufficiently to mitigate liquefaction.

We considered three different ground improvement techniques to densify the in situ soil, including deep dynamic compaction (DDC), vibro-compaction, and compaction grouting. In our opinion, DDC is not a suitable alternative for this site because: (a) the close proximity to other structures, and (b) the required depth of improvement. DDC can result in low-frequency vibrations that could damage nearby structures and utilities. It has been our experience that peak particle velocities exceeding 2 inches per second can occur within 50 feet of the source. Typically, DDC can densify soil to about 20 to 30 feet bgs. The bottom of liquefiable soil is estimated near 45 feet bgs on the site.

Vibro-compaction and compaction grouting are both capable of densifying soil to the depth required for the project, while producing less frequent vibrations. However, vibro-compaction is typically more cost effective than compaction grouting. In our opinion, there is less construction risk associated with vibro-compaction than compaction grouting. Therefore, we recommend using vibro-compaction to densify the soil at the Project site.

7.3.2 Vibro-compaction

Vibro-compaction ground-improvement technique uses vibrating probes (typically having diameters of approximately 1.5 feet) to densify soils. The probe is typically jetted into the ground to the desired depth of improvement and vibrated during withdrawal, causing densification. The soils densify as the probe is repeatedly inserted and withdrawn in
approximately 3-foot increments. Densification will result in settlement at the ground surface, requiring NFS granular backfill during the densification process. Improvement locations are typically positioned on triangular or rectangular grid patterns with center-to-center spacing of 5 to 10 feet. The spacing depends on several factors, including soil type, backfill type, probe type and energy, and level of improvement required. Because the construction means, methods, and equipment will be determined by the ground improvement specialty contractor, the Contractor should be responsible for the actual layout of densification points.

We recommend that the effectiveness of vibro-compaction be verified to confirm the recommended soil improvement has been achieved within the improvement zone. Verification tests should consist of post-treatment soil borings with downhole shear wave velocity measurements conducted midway between densification points. Split spoon samples with penetration values could be collected, but would not be required. All verification tests should be completed with the same equipment, using the same operators, methods, and procedures.

The shear wave velocity tests should be performed in a boring with casing grouted in place. Shear wave velocity measurements should be obtained in each boring on 3-foot intervals from the top to the bottom of the treatment zone. Post-treatment verification tests should not be conducted within 24 hours of grout-injection work. The soil should be densified sufficiently so that the normalized shear wave velocity is greater than 705 feet per second within the treatment zone.

Vibro-compaction can induce ground settlement and ground vibrations. Methods to limit vibration propagation, such as vibration frequency control or other ground improvement techniques should be employed when structures or utilities that could be damaged by vibration are nearby. Performing vibro-compaction ground improvement within 50 feet of utilities, structures, pavement, or other improvements that could be damaged by settlement or vibration should be performed with care. Unless demonstrated to be safe to do so, vibro-compaction ground improvement should not be conducted within 25 feet of sensitive utilities or structures. Where vibro-compaction is performed near structures or critical utilities, we recommend monitoring structure and ground vibrations and structure settlement during vibro-compaction to confirm vibrations and settlement do not exceed tolerable limits. The tolerable vibration and settlement limits for each structure or utility should be selected by the owner and the structural engineer.

### 7.3.3 Deep Soil-improvement Site Preparation

Site preparation for structures where ground improvement is used should include replacing surficial soft, compressible, and/or frost-susceptible materials with a structural fill
down to clean sands and gravels within structure footprints and soil-improvement areas. The base of the excavation should be relatively planar, in relatively clean sands and gravels, and extend approximately 8 to 10 feet below the existing site grade, depending on groundwater elevation.

We suggest maintaining a nominal 5 feet or more of separation between the base of the excavation and groundwater table during vibro-compaction. The base of the excavation should be adjusted as necessary by excavating or filling using material meeting gradation requirements for structural fill. Seasonal frost within the treatment zone should be allowed to thaw or be removed prior to the start of ground improvement.

7.4 Foundation Recommendations for Structures

7.4.1 Boiler/Turbine and Administrative Building

The Boiler/Turbine and Administrative Building is the main structure and is considered an essential structure. The structure could be supported on deep foundations with improved ground to mitigate liquefaction. Mitigating liquefaction will reduce seismic downdrag loads on the piles and provide increased lateral resistance for the piles. We understand a raft foundation is also being considered. If a mat foundation is selected, ground improvement will be required to mitigate liquefaction. Mat foundation recommendations are provided in Section 7.1.2 and Figure 10.

The axial pile capacities for uplift and compression can be estimated using the plots in Figures 11 through 14 and the estimated depth to bedrock shown in Figure 6. The lateral resistance of the piles for this structure can be evaluated using lateral soil parameters presented in Table 1.

We recommend that ground improvement be performed as described in Section 7.3. The soil should be densified down to the top of bedrock, which is estimated to be about 40 to 45 feet bgs at the time of drilling. The soil under the building footprint should be densified. The densified zone should extend a minimum of 25 feet beyond the edge of the structure footprint, as shown in Figure 2.

7.4.2 Stack and Baghouse

The Stack and Baghouse are adjacent to and connected to the Boiler/Turbine Building and are considered essential structures. The Stack and Baghouse could be supported on deep foundations with improved ground to mitigate liquefaction. We understand a raft foundation is also being considered. If a mat foundation is selected, ground improvement will be required to
mitigate liquefaction. Mat foundation recommendations are provided in Section 7.1.2 and Figure 10.

The axial pile capacities for uplift and compression can be estimated using the plots in Figures 11 through 14 and the estimated depth to bedrock shown in Figure 6. The lateral resistance of the piles for these structures can be evaluated using lateral soil parameters presented in Table 1.

We recommend that ground improvement be performed as described in Section 7.3. The soil should be densified down to the top of bedrock, which is estimated to be about 40 feet bgs. The soil under the structure footprint should be densified. The densified zone should extend a minimum of 25 feet beyond the edge of the structure footprint, as shown in Figure 2.

### 7.4.3 Air-cooled Condenser (ACC) Building

The ACC Building is connected to the Turbine Building and must remain functional after a seismic event and is, therefore, considered an essential structure. The loads from the ACC Building could likely be supported by shallow foundations. Ground improvement would also be required to reduce the seismic-induced settlement. Ground improvement should be performed as described in Section 7.3. We understand that the building will likely be supported by continuous and/or spread footings. Recommendations for continuous and spread footings are presented in Section 7.1.1 and Figures 7 and 8.

We recommend that ground improvement be performed as described in Section 7.3. The soil should be densified down to 40 feet bgs at the time of drilling. The soil under the building footprint should be densified. The densified zone should extend a minimum of 25 feet beyond the edge of the structure footprint, as shown in Figure 2.

### 7.4.4 Cold Storage Building and Evaporative Cooling Tower

The Cold Storage Building is considered a non-essential structure. The loads for the Cold Storage Building have not been provided. Depending on the loads, the structure could be supported on shallow or deep foundations. We estimate the seismic settlement near this structure could be about 4 to 13 inches without ground improvement. Because the structure and the equipment in the structure cannot tolerate that amount of settlement, ground improvement will be required with shallow foundations. Shallow foundations can be designed using the recommendations in Section 7.1.1.

We recommend that ground improvement be performed as described in Section 7.3. The soil should be densified down to 60 feet bgs at the time of drilling or the top of bedrock,
whichever is shallower. Ground improvement could be performed under the entire footprint of the building, as shown in Figure 2, or ground improvement could be performed only around the shallow foundations. If ground improvement is performed only around the shallow foundations, the improved zone should extend a minimum of 25 feet around the edge of the foundations. Seismic settlement could still occur between the improved zones. Therefore, if ground improvement is performed only around the foundations, we recommend designing the floor slab to withstand ground loss between the footings.

Alternatively, the Cold Storage Building could be supported on deep foundations. Ground improvement may be necessary to increase lateral resistance of the soil around the piles. Similar to shallow foundations, ground improvement could be performed under the entire building footprint or only around the pile caps. The axial pile capacities for uplift and compression can be estimated using the plots in Figures 11 through 14 and the estimated depth to bedrock shown in Figure 6. The lateral resistance of the piles for these structures can be evaluated using lateral soil parameters presented in Table 1.

7.4.5 Ash Silo, Conveyor, and Crusher

The Ash Silo and Crusher are each connected to the south side of the Boiler Building with conveyors. The Ash Silo and Crusher are considered essential structures. Because of the relatively high loads required to support the Ash Silo and Crusher and the essential nature of the structures, we recommend supporting the structures on deep foundations and ground improvement. The axial pile capacities for uplift and compression can be estimated using the plots in Figures 11 through 14 and the estimated depth to bedrock shown in Figure 6. The lateral resistance of the piles for these structures can be evaluated using lateral soil parameters presented in Table 1.

We recommend that ground improvement be performed as described in Section 7.3. The soil should be densified down to 40 feet bgs at the time of drilling or the top of bedrock, whichever is shallower below the Ash Silo and Crusher Building sites. The soil under the structure footprint should be densified. The densified zone should extend a minimum of 25 feet beyond the edge of the pile caps, as shown in Figure 2.

7.4.6 Elevated Walkway

The elevated walkway that extends from the northwest corner of the Boiler Building to the existing power plant could be supported on shallow or deep foundations. We do not know the loads for the elevated walkway foundations. Shallow or deep foundations could be used, depending on the magnitude of the loads. While deep foundations might be needed near the
Boiler Building where the depth to bedrock is greatest, shallow foundations could likely be used toward the west end of the elevated walkway, where bedrock is expected to be shallower.

For shallow and deep foundations, the upper soft, compressible, and frost-susceptible soil should be removed and replaced with compacted structural fill. Toward the west end of the elevated walkway, if the existing soil is removed and replaced with compacted structural fill down to the top of bedrock, no soil densification would be required. The shallow foundations recommendations provided in Section 7.1.1 can be used for design.

The axial pile capacities for uplift and compression can be estimated using the plots in Figures 11 through 14 and the estimated depth to bedrock shown in Figure 6. The lateral resistance of the piles for the elevated walkway foundations can be evaluated using lateral soil parameters presented in Table 1.

We recommend that ground improvement be performed as described in Section 7.3. The soil should be densified down to the top of bedrock. The top of bedrock varies along the conveyor alignment from about 6 feet up to about 40 feet bgs. The densified zone should extend a minimum of 25 feet beyond the edge of the pile cap or edge of footing.

7.4.7 Thawing Shed, Transfer House, and Coal Unloading Buildings

The Thawing Shed, Transfer House, and Coal Unloading Buildings must remain functional after the seismic event and are, therefore, considered essential structures. The loads from these structures could likely be supported by shallow foundations. Ground improvement would be required to reduce the seismic-induced settlement. We understand that the buildings will likely be supported on continuous spread footings. Recommendations for shallow foundations are presented in Section 7.1.1.

We recommend that ground improvement be performed as described in Section 7.3. The soil should be densified down to 45 feet bgs, at the time of drilling or to the top of bedrock, whichever is shallower. The soil under the building footprint should be densified. The densified zone should extend a minimum of 25 feet beyond the edge of the structure footprint, as shown in Figure 2.

7.5 Lateral Earth Pressures on Basement Walls

We understand the Boiler/Turbine Building will have a basement that is about 12 feet bgs. Lateral pressures against buried walls are dependent on many factors, including method of backfill placement and degree of compaction, backfill slope, surcharges, the type of backfill soil and/or adjacent native soils, drainage, and whether or not the wall can yield or deflect laterally or
rotate at the top after or during backfill placement. For walls allowed to deflect laterally or rotate an amount equal to 0.001 times the wall height, active earth pressures can be used. Rigid buried walls that are not allowed to move should be designed to resist at-rest lateral earth pressures. We recommend using equivalent to fluid weights of 35 and 55 pcf for active and at-rest conditions, respectively. This equivalent fluid weight can be used for design of permanent walls with horizontal backfill and adequate drainage so hydrostatic pressures do not build up behind the wall.

During seismic loading conditions, belowgrade walls will likely move sufficiently to allow active earth pressures to develop, in our opinion. Fore seismic conditions, we recommend designing the buried walls using a static at-rest or active equivalent fluid weight plus a seismic increment of 8H pounds per square foot, where H is the wall height. The seismic earth pressure increment should be applied uniformly over the wall height.

7.6 Subsurface Drainage

The proposed Boiler/Turbine Building basement bottom will be very close to the observed groundwater depth within the Boiler Building footprint. The groundwater depth within the building footprint was observed to be about 12 to 13 feet bgs. Typically, the groundwater elevation may fluctuate by about 2 feet seasonally. Therefore, the bottom of the basement floor slab could be below groundwater. If the basement will be below groundwater, a pump system may be needed.

8.0 DIRECT-BURY UTILITIES

Direct-bury utility lines should be placed on a minimum of 6 inches of compacted material meeting the gradation and compaction requirements for structural fill or bedding material. Bedding material should consist of granular, rounded to sub-rounded material meeting gradation requirements in this report.

Prior to laying the pipe or placing fill, seasonally frozen soils below the base of the trench should be allowed to thaw, and the base of the trench uniformly and systematically proof-compacted with at least four passes of a large, self-propelled, plate compactor. The exact number of passes should be left to the Contractor, so the Contractor is able to achieve the required compaction requirements in the first lift of fill.

After laying the pipe in the trench and establishing line and grade, the pipe should be backfilled up to the springline, on both sides of the pipe at the same time, with bedding material sufficiently compacted so the pipe does not shift or lift. The trench should then be backfilled to 6 inches
above the top of the pipe with additional bedding material. The surface of the bedding material
should then be compacted with a vibratory plate compactor. Compaction of the bedding material
should be accomplished so as not to damage the pipe insulation.

We do not recommend a minimum compaction requirement for the bedding material.
Compaction of the bedding material should be left to the Contractor, so the required compaction
in the first lift of overlying fill is achievable. A uniformly sized product, such as pea gravel,
naturally attains a near-maximum density during placement without compaction; therefore,
compaction or density testing of this type of material is not required.

Abrupt changes in soil conditions should be avoided beneath paved areas to minimize the effects
of frost action. Beneath paved areas, native soils from the trench excavation should be used to
fill the trench between the top of the trench bedding and the base of the pavement section. The
native backfill should meet the requirements for and be compacted in accordance with the
recommendations for non-structural fill in this report. Where the top of the bedding is less than
1 foot below the base of the pavement section, frost-transition zones as described in Section 9.4
of this report are recommended. Structural fill should be used to fill the trench between the top
of the trench bedding and the base of the pavement section.

Where direct-bury utilities connect to a pile-supported structure, there is the potential for
differential settlement during the seismic event. Additionally, where utilities transition from an
improved soil zone to unimproved soil, there is the potential for differential settlement resulting
from liquefaction. The impact of the differential settlement could be mitigated by the use of
joints that allow differential movement. Soil improvement transition zones could also be
incorporated to mitigate abrupt differential movements.

9.0 PAVEMENT SECTIONS

We understand the Project includes paved areas for parking and access drives to adjacent roads.
The minimum pavement sections were designed assuming surficial fills and natural silty soils
across the site are frost susceptible and compressible. We considered the performance of
existing pavement sections in the Fairbanks area and the effects of frost action on pavements.

9.1 Flexible Pavement Design for Driveways and Access Roads

Driveways and access roads to parking areas will likely carry some heavy traffic, including semi-
tractor trailers, in addition to passenger vehicles. We recommend the following pavement
section for the driveways and access roads carrying less than 10 percent heavy traffic loads:
PAVEMENT SECTION RECOMMENDATIONS FOR ACCESS ROADS

<table>
<thead>
<tr>
<th>Course</th>
<th>Minimum Thickness (inches)</th>
<th>Material Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>2</td>
<td>Asphalt concrete</td>
</tr>
<tr>
<td>Base</td>
<td>6</td>
<td>Aggregate base course meeting all the requirements for ADOT&amp;PF grading D-1, compacted to 98 percent of the maximum dry density determined by ASTM D1557.</td>
</tr>
<tr>
<td>Subbase</td>
<td>18</td>
<td>NFS material meeting the structural fill requirements of this report compacted to 95 percent of the maximum dry density determined by ASTM D1557.</td>
</tr>
</tbody>
</table>

Notes:
ADOT&PF = Alaska Department of Transportation and Public Facilities
ASTM = ASTM International
NFS = nonfrost-susceptible

For driveways carrying primarily heavy traffic or equipment loads, the subbase section should be increased to 24 inches in thickness.

9.2 Parking

The parking area traffic will consist primarily of personal vehicles, including light vans and pickup trucks. We recommend the following pavement section for the parking areas:

PAVEMENT SECTION RECOMMENDATIONS, PERSONALLY OWNED VEHICLE PARKING AREAS

<table>
<thead>
<tr>
<th>Course</th>
<th>Minimum Thickness (inches)</th>
<th>Material Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>2</td>
<td>Asphalt concrete</td>
</tr>
<tr>
<td>Base</td>
<td>6</td>
<td>Aggregate base course meeting all the requirements for ADOT&amp;PF grading D-1, compacted to 98 percent of the maximum dry density determined by ASTM D1557.</td>
</tr>
<tr>
<td>Subbase</td>
<td>12</td>
<td>NFS material meeting the structural fill requirements of this report compacted to 95 percent of the maximum dry density determined by ASTM D1557.</td>
</tr>
</tbody>
</table>

Notes:
ADOT&PF = Alaska Department of Transportation and Public Facilities
ASTM = ASTM International
NFS = nonfrost-susceptible
9.3 Site Preparation for Pavement Sections

Driveway, street, and parking areas should be excavated of existing soils to accommodate new pavement sections. Organic soils, such as topsoil and surface organics, should be removed. Once the subgrade is exposed, it should be observed by an engineer from our firm to determine if suitable soils are present or if additional localized overexcavation is required. We recommend the removal of any soft, wet, or highly organic soils or wood and peat from the base of the excavation. Additional excavation should be anticipated to remove organic soils in localized areas. If frozen ground is present at the base of the excavation, the frozen material should be excavated and replaced with thawed compacted fill, or allowed to thaw to a minimum depth of 2 feet below subgrade elevation.

We recommend in situ soil at the base of the excavation be proof rolled with at least four passes of a large, heavy, self-propelled vibratory compactor. The level of compaction effort should be such that the Contractor can achieve 95 percent compaction with the first lift of subbase fill. If the subgrade is not adequately compacted, the Contractor may have difficulty achieving compaction in the first lift of subbase fill.

Note that in the spring or after periods of precipitation, the moisture contents in the silty subgrade soils could be significantly higher than their anticipated optimum moisture content. If silty soils too wet to compact without pumping occur in the base of the excavation, we recommend three options: (a) wait and allow silty soils to dry out naturally, (b) till or otherwise accelerate the natural drying of the wet soils by mechanical means, or (c) excavate an additional 1 foot of subbase, install a separation geotextile, and float an initial 1-foot-thick lift of structural fill on top of the separator. No specific degree of compaction is recommended for this layer; however, it should be compacted enough to allow the next lift to be compacted to 95 percent of the modified Proctor value (ASTM D1557).

If a separation geotextile is used, we recommend the separation geotextile conform to the requirements of AASHTO M 288 for a Class 2 geotextile with an elongation of greater than or equal to 50 percent. The Class 2 geotextile should conform to the requirements of Table 3; Separation Geotextile Property Requirements in AASHTO M 288, except the minimum permittivity of the fabric should be 0.05 centimeter per second. The separation geotextile should have an apparent opening size equal to, or between, the No. 70 and No. 100 U.S. Standard Sieve as determined by ASTM D4751. Class 2 geotextiles may be joined either by sewing or overlapping.
9.4 Frost Transitions

Beneath pavement sections, gradual transitions are recommended between the thick sections of nonfrost-susceptible (NFS) structural fills and adjacent frost-susceptible subgrade soils. The transitions serve to spread out differential movements due to frost heaving. Frost transitions should be provided by sloping the interface between NFS structural fills and adjacent frost-susceptible subgrade soils no steeper than 5 Horizontal to 1 Vertical (5H:1V).

10.0 RAILROAD SPUR

10.1 General

We understand that a short railroad spur will be constructed to bring the coal cars from the main track to the coal unloading building and then return to join the main track. The proposed railroad track location is shown in Figure 2. We understand that the track will be at grade for most of the alignment. However, the track will have to rise about 5 feet in elevation to meet the grade of the main track after it exits the structure.

The subsurface conditions along the proposed track alignment vary. Our borings suggest fill is present in the upper 2 to 3 feet. The fill is generally underlain by loose to medium dense sand and silt. Based on observed subsurface conditions the potential for large deformation or settlement of railroad track structure constructed in the proposed location is low, provided our recommendations for site preparation are followed.

We recommend constructing the new rail embankment section using compacted, NFS structural fill. Conceptually, the embankment would be a maximum of 5 feet high. NFS structural fill embankment slopes should be no steeper than 2H:1V.

10.2 Site Preparation for Rail Embankments

Areas within the footprint of the embankment should be prepared by clearing and grubbing vegetation, organics, and peat down to mineral soil. We recommend the removal of any soft, wet, or highly organic soils from the base of the excavation.

After the organics are removed, we recommend allowing the seasonal frost to thaw prior to embankment construction to reduce the magnitude of post construction settlement.

After the subgrade has thawed, we recommend that the in situ soil at the base of the excavation be proof rolled with a heavy compactor. The level of compaction effort should be such that the Contractor can achieve the required compaction in subsequent lifts. If the base of the excavation
and subgrade is not adequately compacted, the Contractor will have difficulty compacting the first lift of the overlying fill. We recommend placing either a mineral filter or geotextile separator between the silt subgrade and the classified embankment fill.

Depending on the time of construction and weather patterns, the moisture contents in the silty subgrade soils could be significantly higher than their anticipated optimum moisture content. If moist to wet, silty soils are too wet or soft to compact without pumping, we recommend three options: (a) allow silty soils to dry out naturally, (b) till or otherwise accelerate the natural drying of the wet soils by mechanical means, or (c) excavate an additional 1 foot of subgrade, install a geosynthetic separator, and float an initial 1-foot-thick lift of granular fill on top of the separator. No specific degree of compaction is recommended for this layer; however, it should be compacted well enough to allow the next lift to be compacted to the proper density. Also, if silty soils become wet due to precipitation (or other means) the placement of fill may need to be delayed until the soils dry out. We suggest the Contractor limit the exposure of silty soils to moisture from precipitation events to facilitate construction.

10.3 Ballast

For embankments consisting of structural fill and constructed in accordance with the recommendations in Section 10.2, we recommend placing a minimum thickness of 8 inches (compacted) of ballast. This thickness is measured from the bottom of tie. Ballast used on this project should conform to the types, characteristics, and property requirements specified in the American Railway Engineering and Maintenance-of-Way Association Manual for Railway Engineering (AREMA, 2014) Sections 2.2 through 2.4.

10.4 Subballast

Before placing ballast, we recommend placing a minimum of 8 inches (compacted thickness) of subballast over the top of the compacted embankment surface. Subballast materials should meet the material quality and gradation requirements specified in AREMA Section 2.11. Placement and compaction of the subballast should be performed in accordance with AREMA Section 2.11.4.
11.0 MATERIALS

11.1 Structural Fill

Structural fill should consist of unfrozen, NFS gravelly sand or sandy gravel meeting the following gradation limits after compaction:

<table>
<thead>
<tr>
<th>Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-inch</td>
<td>100</td>
</tr>
<tr>
<td>No. 4 sieve</td>
<td>30 to 60</td>
</tr>
<tr>
<td>No. 200 sieve</td>
<td>0 to 5</td>
</tr>
</tbody>
</table>

Soils meeting this gradation criterion are commonly available from local sources as pit-run sand and gravel.

Structural fill, placed with large, self-propelled vibratory rollers, should be placed in layers not exceeding 12 inches in loose height; the material in each layer should be compacted to achieve a density of at least 95 percent of the maximum dry density based on the Modified Proctor moisture-density relationship (ASTM D1557). ASTM D6938 should be used to determine in-place densities. The fill should consist of unfrozen materials and be placed at above-freezing air temperatures. If previously placed fill freezes, for instance overnight, the frozen material should be excavated and wasted or allowed to thaw and recompacted prior to placement of additional fill.

11.2 Non-structural Fill

Non-structural fill may be used to fill or shape unpaved areas. Non-structural fill may consist of silt or silty soils from the excavation; however, the fill should not contain topsoil or organics. Maximum loose lift height for nonstructural fill should not exceed 8 inches. This material should be compacted to at least 92 percent of the maximum density obtained from the Modified Proctor compaction test (ASTM D1557). Drying or wetting of the soil may be necessary to obtain compaction.

The compaction of sandy silt with small vibratory compactors, particularly smaller hand-operated equipment, should be expected to be difficult. If hand-operated compactors (jumping jacks) are used to compact excavated materials, the loose-lift thickness should not exceed 6 inches.
11.3 **Bedding**

Bedding material should consist of unfrozen, granular, rounded to sub-rounded material meeting the following gradation limits after compaction:

<table>
<thead>
<tr>
<th>Size</th>
<th>Percentage Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>½-inch</td>
<td>100</td>
</tr>
<tr>
<td>No. 4 sieve</td>
<td>Less than 40</td>
</tr>
<tr>
<td>No. 200 sieve</td>
<td>Less than 5</td>
</tr>
</tbody>
</table>

Clean sands and gravel from on-site excavations or borrow sources meeting these gradation requirements may be used as bedding material. The use of angular, crushed gravel is not recommended for pipe bedding.

We do not recommend a minimum compaction requirement for bedding material. The selection of compaction equipment and effort should be left to the Contractor, such that the Contractor is able to achieve recommended compaction in the first lift of overlying fill.

A uniformly sized product, such as pea gravel, naturally attains a near-maximum density during placement with very little compaction; therefore, compaction or density testing of this type of material is not required.

12.0 **CONSTRUCTION CONSIDERATIONS**

12.1 **Site Preparation**

Site preparation should begin by clearing and grubbing all trees, organics, and debris down to mineral soils; the excavations should then extend to the minimum elevation required for design. After the planned base of excavation is reached and before placement of fill, the base of the excavations should be observed to determine if additional excavation is required to remove localized areas of undesirable soils such as high moisture content frozen soils, organic soils, and soft compressible soils.

In deeper portions of the excavations, or during periods of high groundwater levels, it is possible excavation below the water table may be necessary. It has been our experience that shallow excavation and replacement below the water table can be successfully accomplished without dewatering. We recommend keeping the excavated area below the water as small as possible by backfilling immediately as the excavation proceeds.
Excavations should be wide enough to accommodate large self-propelled compactors. The base of excavations should be proof rolled and compacted to achieve a density suitable for the placement of fill. If the subgrade is not compacted adequately, it will be difficult for the Contractor to achieve the required density with the first lift of fill. Any soft soils discovered in the base of the excavation should be excavated and replaced with compacted structural fill. Proof rolling of the in situ soils will allow the observing geotechnical engineer to identify soft spots which may be present near the base of the excavation.

Following compaction of the base, the excavation should be backfilled with structural fill as necessary according to the recommendations given in this report. Soils excavated from the site that meet the gradation requirements for structural fill can be reused as fill, provided it is placed and compacted in controlled lifts as described under the requirements for classified material.

12.2 Temporary Slopes

All excavations should be sufficiently sloped or shored to provide a stable bank. We recommend the stability of the excavated slopes be made the responsibility of the Contractor, as they will be most familiar with conditions encountered in the excavations and have direct control of working conditions in the field. The work should be accomplished in general accordance with applicable local, state, and federal standards. For planning purposes, we recommend you assume unsupported excavation slopes will be no steeper than 1H:1V. Heavy construction equipment and loaded dump trucks may need to be kept 10 feet or more away from the slope crest. The potential construction equipment loading should be considered by the Contractor when evaluating the excavation slope stability. It is important to note that temporary excavation slopes may initially stand steep but slough and cave as they dry out, particularly when equipment is operated nearby. Similarly, steep cuts made in seasonally frozen ground can become unstable upon thawing.

Temporary slopes could be constructed to partially backfill the excavation. Temporary slopes should be the responsibility of the Contractor because they are on site and are in control of the work. For planning purposes, temporary slopes constructed using well compacted structural fill and good construction practices could be constructed at 2H:1V to support vehicular traffic. Heavy construction equipment and trucks should be kept a minimum of 10 feet from the slope crest.

12.3 Surface Drainage

During construction of the project, the ground surface should be sloped away from open excavations to reduce water inflow into any excavations. Water should not be allowed to pond on
or adjacent to structures. Following construction, the site should be graded to provide positive drainage away from structures, roadways, and parking areas.

13.0 LIMITATIONS

Subsurface explorations and testing will identify subsurface conditions only at those points where samples are taken, and at the time they are taken. Actual conditions at other locations of the project site, including those inferred to exist between sample points, may differ significantly from conditions existing at the sampling locations. The passage of time or intervening causes may change the actual conditions at the sampling locations as well.

Interpretations and recommendations made by Shannon & Wilson are based solely upon information available to Shannon & Wilson at the time the interpretations and recommendations are made.

All documents prepared by Shannon & Wilson are instruments of service with respect to the project for the sole use of our client. Only our client shall have the right to rely upon such documents. Such documents are not intended or represented to be suitable for reuse. Any such reuse without written verification or adaptation by Shannon & Wilson, as appropriate for the specific purpose intended, shall be at the user’s sole risk.

Copies of documents that may be relied upon by our client are limited to the printed copies (also known as hard copies) signed or sealed by Shannon & Wilson. Text, data, or graphics files in electronic media format are furnished solely for our client’s convenience. Any conclusion or information obtained or derived from such electronic files shall be at the user’s sole risk. If there is a discrepancy between the electronic files and the hard copies, the hard copies govern.

Shannon & Wilson has prepared Appendix E, “Important Information About Your Geotechnical/Environmental Report,” to assist you and others in understanding the uses and limitations of our reports.

SHANNON & WILSON, INC.

Steve Adamczak, Jr., P.E.
Vice President

IAS:WLM:SA/ias
14.0 REFERENCES


American Society of Civil Engineers (ASCE), 2005, Minimum design loads for buildings and other structures: ASCE Standard SEI/ASCE 7-05, international system of units (SI) and customary units, Reston, Virginia.


### TABLE 1
RECOMMENDED PARAMETERS FOR DEVELOPMENT OF P-Y CURVES USING LPILE

<table>
<thead>
<tr>
<th>Soil Unit</th>
<th>LPILE Soil Type</th>
<th>Effective Unit Weight (pcf)</th>
<th>Cohesion (psf)</th>
<th>Friction Angle (degrees)</th>
<th>Modulus of Horizontal Subgrade Reaction (pci)</th>
<th>Strain at 50% Maximum Stress Difference $e_{50}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Fill / Improved Ground Above Groundwater</td>
<td>API SAND</td>
<td>125</td>
<td>0</td>
<td>34</td>
<td>90</td>
<td>-</td>
</tr>
<tr>
<td>Structural Fill / Improved Ground Below Groundwater</td>
<td>API SAND</td>
<td>58</td>
<td>0</td>
<td>34</td>
<td>65</td>
<td>-</td>
</tr>
</tbody>
</table>

pci = pounds per cubic inch  
pcf = pounds per cubic foot  
psf = pounds per square foot
## TABLE 2
### RECOMMENDED P-MULTIPLIERS FOR GROUP EFFECTS

<table>
<thead>
<tr>
<th>Group Type</th>
<th>Shaft Spacing (Dia.)</th>
<th>Recommended Reduction Factors</th>
<th>Loading Type-2</th>
<th>Loading Type-3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Row 1</td>
<td>Row 2</td>
</tr>
<tr>
<td>Groups with 1 Row</td>
<td>2.0D</td>
<td>0.54</td>
<td>1.00</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>3.0D</td>
<td>0.80</td>
<td>1.00</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>5.0D</td>
<td>1.00</td>
<td>1.00</td>
<td>0.85</td>
</tr>
</tbody>
</table>

**Note:**
Linear interpolation can be used to calculate the P-Multipliers for the shaft spacings which are not listed above.

### LOADING TYPE - 1
![Diagram](http://example.com/1.png)

**Applied Load**

### LOADING TYPE - 2
![Diagram](http://example.com/2.png)

**Applied Load**

### LOADING TYPE - 3
![Diagram](http://example.com/3.png)

**Applied Load**
University of Alaska Fairbanks
Heat and Power Plant Replacement
Fairbanks, Alaska

NOTE
Map adapted from aerial imagery provided by Google Earth Pro, reproduced by permission granted by Google Earth™ Mapping Service.
FIG. 3

SHEAR AND COMPRESSION WAVE DATA
BORING 14-02

University of Alaska Fairbanks
Heat and Power Plant Replacement
Fairbanks, Alaska

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

December 2014

31-1-02399-001

0 50 100 150 200

0 2500 5000 7500 10000 12500

0 20 40 60 80

0 10 20 30 40

0 5 10 20 30

0 50 100 150 200

University of Alaska Fairbanks
RFP No. 15P0015MG - Air-Cooled Condensing System
Amendment No. 5

DocuSign Envelope ID: D6847BF8-75A1-4084-882F-CE473BAA93EE

S-Wave
P-Wave

P-Wave
S-Wave

P-Wave
S-Wave
**SHEAR AND COMPRESSION WAVE DATA**
**BORING 14-03**

University of Alaska Fairbanks
Heat and Power Plant Replacement
Fairbanks, Alaska

December 2014

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants
SHEAR AND COMPRESSION
WAVE DATA
BORING 14-06
December 2014
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants
FIG. 5
University of Alaska Fairbanks
Heat and Power Plant Replacement
Fairbanks, Alaska

ESTIMATED DEPTH TO BEDROCK
December 2014
31-1-02399-001

Scale = 1:600

Legend:

- 1997 / 1998 Boring, ID & Depth to Bedrock
- 2012 / 2014 Boring, ID & Depth to Bedrock
- Depth to Bedrock: 3-ft. Contours
- Proposed Structures
- Existing Structures
- Ground Elevation: 1-ft. Contours

University of Alaska Fairbanks
RFP No. 15P0015MG - Air-Cooled Condensing System
Amendment No. 5

Date: 9/8/2014

DocuSign Envelope ID: D6847BF8-75A1-4084-882F-CE473BAA93EE
Figure 7

B - Footing width.
D - distance between bottom of footing and top of densified in situ soil

Legend:
- Structural Fill
- Nonstructural Fill or Pavement Section
- Densified In Situ Soils

Note:
This figure is not a construction drawing and should be used for planning purposes only.

University of Alaska, Fairbanks
Heat and Power Plant Replacement
Fairbanks, Alaska

SHALLOW FOUNDATION RECOMMENDATIONS
2014

31-1-02399-001

Figure 7
1. Analyses were performed based on Allowable Stress Design (ASD) guidelines in the International Building Code (IBC) 2009.

2. The allowable bearing pressures include a Factor of Safety of 3.0. The allowable bearing pressure can be increased by one-third for seismic analysis.

3. ksf = kips per square foot
Analyses were performed based on Allowable Stress Design (ASD) guidelines in the International Building Code (IBC) 2009.

2. The allowable bearing pressures include a Factor of Safety of 3.0. The allowable bearing pressure can be increased by one-third for seismic analysis.

3. ksf = kips per square foot
1. Analysis assumes loose, native granular material is densified to a medium dense condition. Post-densified elastic compression parameters were derived from in situ shear wave velocity testing.

2. Thickness of compressible material can be calculated by subtracting the bedrock elevation from the base-of-foundation elevation. Bedrock elevation may be estimated using Figure 6.

3. ksf = kips per square foot, in. = inches
ULTIMATE AXIAL CAPACITY (tons)

0 50 100 150 200 250 300 350 400

NOTES

1. Allowable compressive capacity should be determined by applying a factor-of-safety of 2.0 and 1.1 for static and seismic conditions, respectively. Allowable uplift capacities should be determined by applying a factor-of-safety of 3.0 and 1.5 for static and seismic conditions, respectively.

2. Calculations assume loading conditions for a single pile. Pile group effects are not considered.

3. Estimated axial capacities assume piles are driven to refusal in bedrock.

4. Estimated pile capacity for specific locations should be selected based on the top of bedrock as shown in Figure 3.
Allowable compressive capacity should be determined by applying a factor-of-safety of 2.0 and 1.1 for static and seismic conditions, respectively. Allowable uplift capacities should be determined by applying a factor-of-safety of 3.0 and 1.5 for static and seismic conditions, respectively.

Calculations assume loading conditions for a single pile. Pile group effects are not considered.

Estimated axial capacities assume piles are driven to refusal in bedrock.

Estimated pile capacity for specific locations should be selected based on the top of bedrock as shown in Figure 3.

Notes:

1. Allowable compressive capacity should be determined by applying a factor-of-safety of 2.0 and 1.1 for static and seismic conditions, respectively. Allowable uplift capacities should be determined by applying a factor-of-safety of 3.0 and 1.5 for static and seismic conditions, respectively.

2. Calculations assume loading conditions for a single pile. Pile group effects are not considered.

3. Estimated axial capacities assume piles are driven to refusal in bedrock.

4. Estimated pile capacity for specific locations should be selected based on the top of bedrock as shown in Figure 3.
NOTE

1. Allowable compressive capacity should be determined by applying a factor-of-safety of 2.0 and 1.1 for static and seismic conditions, respectively. Allowable uplift capacities should be determined by applying a factor-of-safety of 3.0 and 1.5 for static and seismic conditions, respectively.

2. Calculations assume loading conditions for a single pile. Pile group effects are not considered.

3. Estimated axial capacities assume piles are driven to refusal in bedrock.

4. Estimated pile capacity for specific locations should be selected based on the top of bedrock as shown in Figure 3.
NOTES

1. Allowable compressive capacity should be determined by applying a factor-of-safety of 2.0 and 1.1 for static and seismic conditions, respectively. Allowable uplift capacities should be determined by applying a factor-of-safety of 3.0 and 1.5 for static and seismic conditions, respectively.

2. Calculations assume loading conditions for a single pile. Pile group effects are not considered.

3. Estimated axial capacities assume piles are driven to refusal in bedrock.

4. Estimated pile capacity for specific locations should be selected based on the top of bedrock as shown in Figure 3.
APPENDIX A

SOIL AND ROCK CLASSIFICATION SYSTEM AND BORING LOGS
# APPENDIX A

SOIL AND ROCK CLASSIFICATION SYSTEM AND BORING LOGS

## TABLE OF CONTENTS

### FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-1</td>
<td>Log of Boring 14-01</td>
</tr>
<tr>
<td>A-2</td>
<td>Log of Boring 14-02 (2 sheets)</td>
</tr>
<tr>
<td>A-3</td>
<td>Log of Boring 14-03 (2 sheets)</td>
</tr>
<tr>
<td>A-4</td>
<td>Log of Boring 14-04 (2 sheets)</td>
</tr>
<tr>
<td>A-5</td>
<td>Log of Boring 14-05 (3 sheets)</td>
</tr>
<tr>
<td>A-6</td>
<td>Log of Boring 14-06 (2 sheets)</td>
</tr>
<tr>
<td>A-7</td>
<td>Log of Boring 14-07 (2 sheets)</td>
</tr>
<tr>
<td>A-8</td>
<td>Log of Boring 14-08 (2 sheets)</td>
</tr>
<tr>
<td>A-9</td>
<td>Log of Boring 14-09</td>
</tr>
<tr>
<td>A-10</td>
<td>Log of Boring 14-10</td>
</tr>
<tr>
<td>A-11</td>
<td>Log of Boring 14-11</td>
</tr>
<tr>
<td>A-12</td>
<td>Log of Boring 14-12</td>
</tr>
<tr>
<td>A-13</td>
<td>Log of Boring 14-13</td>
</tr>
<tr>
<td>A-14</td>
<td>Log of Boring 14-14</td>
</tr>
</tbody>
</table>
SOIL AND ROCK CLASSIFICATION

Soil samples were classified in accordance with Shannon & Wilson’s soil classification system. This system is generally based on the Unified Soil Classification System (USCS) presented in ASTM D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System). The soil classification system provides for the identification of the following characteristics in the order that they are listed.

a) Relative density or consistency – The relative consistency or density of the material is estimated based on the penetration resistance of unfrozen soil. The relative consistency is used to describe fine-grained cohesive soils (such as clay), and the relative density is used to define coarse-grained granular soils (such as sand). The penetration resistance is calculated by summing the blows required to drive the split-spoon sampler the final 12 inches of an 18-inch sample run. The penetration resistance is not valid in frozen soils. Relative density or consistency is determined according to the following table.

<table>
<thead>
<tr>
<th>Penetration Resistance (blows per foot)</th>
<th>Relative Consistency</th>
<th>Penetration Resistance (blows per foot)</th>
<th>Relative Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 2</td>
<td>Very Soft</td>
<td>0 – 4</td>
<td>Very Loose</td>
</tr>
<tr>
<td>2 – 4</td>
<td>Soft</td>
<td>4 – 10</td>
<td>Loose</td>
</tr>
<tr>
<td>4 – 8</td>
<td>Medium Stiff</td>
<td>10 – 30</td>
<td>Medium Dense</td>
</tr>
<tr>
<td>8 – 15</td>
<td>Stiff</td>
<td>30 – 50</td>
<td>Dense</td>
</tr>
<tr>
<td>15 – 30</td>
<td>Very Stiff</td>
<td>&gt; 50</td>
<td>Very Dense</td>
</tr>
<tr>
<td>&gt; 30</td>
<td>Hard</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b) Color – Color descriptions are generally kept as simple as practical, using basic soil colors such as brown, gray, and tan. Color is generally used to distinguish soil layers or indicate the degree of weathering within a single soil layer.

c) Minor Constituents, Major Constituents, and Trace Constituents – In the field, visual manual procedures are used to classify the soil type. The constituents are generally limited to (in decreasing size) boulders, cobbles, gravel, sand, silt, and clay. Minor constituents are soil types that comprise a significant portion of the sample (more than 5 percent), but are not the largest component of the sample. Minor constituents that comprise between 5 and 12 percent of the sample are identified as “slightly.” The major constituent is the one that comprises the largest fraction of the soil mass. The major constituent will generally appear in the form of all capital letters, such as SILT. Trace constituents are soil types that are observed in the soil sample but comprise a limited portion of the sample. The presence of these soil types may or may not influence the behavior of the soil.
Organics may also be considered as constituents in the soil description. The following terms are used to describe the organic content.

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>Percent by Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occasional</td>
<td>0 – 1</td>
</tr>
<tr>
<td>Scattered</td>
<td>1 – 10</td>
</tr>
<tr>
<td>Numerous</td>
<td>10 – 30</td>
</tr>
<tr>
<td>Organic</td>
<td>Minor constituent</td>
</tr>
<tr>
<td>PEAT</td>
<td>Major constituent</td>
</tr>
</tbody>
</table>

d) Moisture content – The relative moisture content (dry, slightly moist, moist, or wet) is given to the sample based on observations of the sample. This is a qualitative description that assists the engineer in identifying how the sample may behave at that particular moisture content.

e) Other – following the relative moisture content, the geologist or engineer may also include additional observations that will describe the characteristics or behavior of the soil. These terms include structure, plasticity, gradation, grain shape, cementation, description of organics, or dilatancy. Some of these descriptions are presented in the following tables.

f) Structure

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>Criteria, Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parting</td>
<td>0 – 1/16 inch</td>
</tr>
<tr>
<td>Seam</td>
<td>1/16 – ½ inch</td>
</tr>
<tr>
<td>Layer</td>
<td>&gt; ½ inch</td>
</tr>
<tr>
<td>Lamination</td>
<td>&lt; ¼ inch</td>
</tr>
<tr>
<td>Pocket</td>
<td>Irregular, &lt; 1 foot</td>
</tr>
<tr>
<td>Varved</td>
<td>Alternating seams or laminations</td>
</tr>
<tr>
<td>Occasional</td>
<td>&lt; 1 per foot</td>
</tr>
<tr>
<td>Frequent</td>
<td>&gt;= 1 per foot</td>
</tr>
<tr>
<td>Stratified</td>
<td>Alternating layers</td>
</tr>
<tr>
<td>Interbedded</td>
<td>Alternating layers &gt; ½ inch thick</td>
</tr>
<tr>
<td>Laminated</td>
<td>Alternating layers &lt; ¼ inch thick</td>
</tr>
<tr>
<td>Fractured</td>
<td>Breaks easily along definite fractured planes</td>
</tr>
<tr>
<td>Slickensided</td>
<td>Polished, glossy, striated fractured planes</td>
</tr>
<tr>
<td>Blocky, Dice</td>
<td>Easily breaks into small angular lumps</td>
</tr>
<tr>
<td>Homogeneous</td>
<td>Same color and appearance throughout</td>
</tr>
<tr>
<td>Sheared</td>
<td>Disturbed texture, mix of strengths</td>
</tr>
</tbody>
</table>
g) Plasticity

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>Criteria, Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonplastic Low</td>
<td>A 1/8-inch thread cannot be rolled at any water content</td>
</tr>
<tr>
<td>Medium</td>
<td>The thread can be rolled and the lump cannot be formed when drier than the plastic limit. The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.</td>
</tr>
<tr>
<td>High</td>
<td>It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.</td>
</tr>
</tbody>
</table>

h) Frozen Soil - Shannon & Wilson’s frozen soil classification is based on the descriptions developed by Linell and Kaplar (1966). The frozen soil descriptions are primarily based on visual observations regarding the presence, orientation, and form of ice. A summary of the Linnel and Kaplar classification is presented below.

<table>
<thead>
<tr>
<th>Description</th>
<th>Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Segregated ice is not visible by eye</td>
<td>Friable, poorly bonded Material is easily broken up</td>
</tr>
<tr>
<td>Segregated ice is visible by eye (less than 1-inch thick)</td>
<td>Individual ice crystals or inclusions Ice coatings on soil particles Stratified or distinctly oriented ice formations Randomly or irregularly oriented ice formations</td>
</tr>
<tr>
<td>Ice greater than 1-inch thick</td>
<td>Ice with soil inclusions Ice without soil inclusions</td>
</tr>
</tbody>
</table>


In addition to describing the presence, orientation and form of ice, our soil classification may also include a visual volumetric estimation of ice content and a description of the size and orientation of individual ice features.
MATERIAL DESCRIPTION

Approximate Elevation: 439.3 ft

Medium Dense, brown, Poorly Graded Sand with Gravel and Silt (SP-SM); moist. (Fill)

Very loose to medium dense, gray-brown, Poorly Graded Gravel with Silt and Sand (GP-GM); moist. (Fill)

Very loose, gray-brown, Sandy Silt (ML); moist.

Loose, brown, Poorly Graded Sand (SP); moist.

Loose, dark gray, Silty Sand (SM); very moist

Loose to medium dense, brown, Poorly Graded Gravel with silt and Sand (GP-GM); wet

Schist: very low strength, gray-brown, schistose, completely weathered (Birch Creek Schist).

Bottom of Boring
Boring Completed 6/19/2014

Legends:
- Sample Not Recovered
- Ground Water Level At Time Of Drilling
- Water Content (%)
- % Fines (<0.075mm)
- 3" O.D. Split Spoon Sample
- Grab Sample
- Rock Core Sample

Notes:
1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
# MATERIAL DESCRIPTION

Approximate Elevation: 437.4 ft

<table>
<thead>
<tr>
<th>DEPTH, ft</th>
<th>SYMBOL</th>
<th>SAMPLES</th>
<th>GROUND WATER DEPTH, ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
<td>40</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>0.0</th>
<th>5.0</th>
<th>10.0</th>
<th>15.0</th>
<th>20.0</th>
<th>25.0</th>
<th>30.0</th>
<th>35.0</th>
<th>40.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

## NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
**MATERIAL DESCRIPTION**

<table>
<thead>
<tr>
<th>SAMPLES</th>
<th>SYMBOLS</th>
<th>DEPTH, ft</th>
<th>GROUND WATER DEPTH, ft</th>
<th>SAMPLES</th>
<th>GROUND WATER DEPTH, ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-12</td>
<td>S-13</td>
<td>40.5</td>
<td>0</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>S-14</td>
<td></td>
<td></td>
<td>30</td>
<td>40</td>
</tr>
</tbody>
</table>

Approximate Elevation: 437.4 ft

**NOTES**

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.

---

**LEGEND**

- Sample Not Recovered
- 3" O.D. Split Spoon Sample
- Grab Sample
- Rock Core Sample
- Frozen

**Univeristy of Alaska Fairbanks**

Heat and Power Plant Replacement

Fairbanks, Alaska

**LOG OF BORING 14-02**

2014 31-1-02399-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants
Figure A-2 Sheet 2 of 3
### MATERIAL DESCRIPTION

**Approximate Elevation:** 437.4 ft

<table>
<thead>
<tr>
<th>DEPTH, ft</th>
<th>SYMBOL</th>
<th>SAMPLES</th>
<th>PID (ppm)</th>
<th>GROUND WATER DEPTH, ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Bottom of Boring**  
Boring Completed 6/10/2014

---

### LEGEND

- \[\text{Sample Not Recovered}\]
- \[\text{3" O.D. Split Spoon Sample}\]
- \[\text{Grab Sample}\]
- \[\text{Rock Core Sample}\]
- \[\text{Frozen}\]

### NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
### MATERIAL DESCRIPTION

Approximate Elevation: 436.8 ft

<table>
<thead>
<tr>
<th>DEPTH, ft</th>
<th>SYMBOL</th>
<th>SAMPLES</th>
<th>GROUND WATER DEPTH, ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>S-1</td>
<td>G-1</td>
<td>0</td>
</tr>
<tr>
<td>2.0</td>
<td>S-2</td>
<td>S-1</td>
<td>10</td>
</tr>
<tr>
<td>8.0</td>
<td>S-3</td>
<td>S-1</td>
<td>20</td>
</tr>
<tr>
<td>8.0</td>
<td>S-4</td>
<td>S-1</td>
<td>30</td>
</tr>
<tr>
<td>12.0</td>
<td>S-5</td>
<td>S-1</td>
<td>40</td>
</tr>
<tr>
<td>12.0</td>
<td>S-6</td>
<td>S-1</td>
<td>50</td>
</tr>
<tr>
<td>14.5</td>
<td>S-7</td>
<td>S-1</td>
<td>60</td>
</tr>
<tr>
<td>14.5</td>
<td>S-8</td>
<td>S-1</td>
<td>70</td>
</tr>
<tr>
<td>18.5</td>
<td>S-9</td>
<td>S-1</td>
<td>80</td>
</tr>
<tr>
<td>18.5</td>
<td>S-10</td>
<td>S-1</td>
<td>90</td>
</tr>
<tr>
<td>38.5</td>
<td>S-11</td>
<td>S-1</td>
<td>100</td>
</tr>
</tbody>
</table>

**MATERIAL DESCRIPTION**

- **Brown, Poorly Graded Sand with Gravel (GP); moist. (Fill)**
- **Loose, gray brown, Poorly Graded Sand with Silt and Gravel (SM); moist to frozen, Nf from 6 to 7 feet. (Fill)**
- **Loose, dark brown, Peat, moist.**
- **Loose, gray brown, interbedded, Sandy Silt (ML) and Silty Sand (SM) to moist.**
- **Loose, gray brown, Poorly Graded Sand with Silt and Gravel (SP-SM); wet.**
- **Very loose, gray brown, Poorly Graded Sand (SP); wet; trace gravel.**
- **Loose to medium dense, gray brown, Well Graded to Poorly Graded Gravel with Sand (GW) and (GP); wet.**

**NOTES**

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.

**LEGEND**

- * Sample Not Recovered
- ** 3" O.D. Split Spoon Sample
- I Grab Sample
- II Rock Core Sample
- ● Water Content (%)
- ▲ Ground Water Level At Time Of Drilling
- ▲ % Fines (<0.075mm)

**University of Alaska Fairbanks**
**Heat and Power Plant Replacement**
**Fairbanks, Alaska**

**LOG OF BORING 14-03**

2014 31-1-02399-001

**SHANNON & WILSON, INC.**
Geotechnical and Environmental Consultants

Figure A-3
Sheet 1 of 3
The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.

The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.

Water level, if indicated above, is for the date specified and may vary.

Notes

1. Sample Not Recovered
2. Water Level, if indicated above, is for the date specified and may vary.
### MATERIAL DESCRIPTION

**Approximate Elevation:** 436.8 ft

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>SAMPLES</th>
<th>DEPTH, ft</th>
<th>GROUND WATER DEPTH, ft</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>81.0</td>
<td></td>
</tr>
</tbody>
</table>

**Bottom of Boring**

**Boring Completed 6/17/2014**

---

### LEGEND

- * Sample Not Recovered
- \( \text{\%} \) Ground Water Level At Time Of Drilling
- % Fines (≤0.075mm)
- Water Content (%)

### NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
Dark brown, Poorly Graded Sand with Silt and Gravel (SP-SM); moist; rooted.

Loose, light gray brown, Silty Sand (SM); moist.

Loose, gray brown, interbedded, Sandy Silt (ML) to Sandy Silt (SM); moist; decreasing silt content with depth.

Loose, gray brown, Poorly Graded Sand with Silt (SP-SM); moist.  
Loose to medium dense, interbedded, Poorly Graded Sand with Gravel (SP) and Poorly Graded to Well Graded Gravel with Sand (GP) and (GW); moist to wet below 12 feet.

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
Schist: very low to low strength, gray brown, schistose, foliated, quartz veins, highly to completely weathered (Birch Creek Schist)

**NOTES**

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.

---

**LEGEND**

- *: Sample Not Recovered
- ▲: Ground Water Level At Time Of Drilling
- %: % Fines (<0.075mm)
- H: Rock Core Sample
- II: 3" O.D. Split Spoon Sample
- △: Water Content (%)
Brown, Poorly Graded Sand with Silt and Gravel (SP-SM); moist.

- Dark Brown, Silt with Sand (ML); moist.
- Loose, gray brown, Poorly Graded Silty Sand (SM); moist.

Loose, gray brown, Poorly Graded Sand (SP); moist to wet below 13 feet; few gravel.

- Loose to medium dense, gray brown, Well Graded to Poorly Graded Gravel with Sand (GW) and (GP); wet.
- Layer of poorly graded sand from 17.8 to 19.5 feet

---

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.

2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.

3. Water level, if indicated above, is for the date specified and may vary.
MATERIAL DESCRIPTION

Approximate Elevation: 436.7 ft

- Schist: very low strength, gray brown, schistose, completely weathered (Birch Creek Schist)
- Schist: very low strength, gray brown, schistose, highly weathered (Birch Creek Schist)
- Schist: medium to high strength, gray brown, schistose, moderately weathered (Birch Creek Schist)

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
**MATERIAL DESCRIPTION**

Approximate Elevation: 436.7 ft

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>SAMPLES</th>
<th>GROUND WATER DEPTH, ft</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0 10 20 30 40 50</td>
</tr>
<tr>
<td>S-17</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>85 90 95 100 105 110</td>
</tr>
<tr>
<td></td>
<td></td>
<td>115</td>
</tr>
</tbody>
</table>

**LEGEND**

- * Sample Not Recovered
- ⚫ Ground Water Level At Time Of Drilling
- ▲ % Fines (<0.075mm)
- ★ Water Content (%)
- ▼ 3" O.D. Split Spoon Sample
- ⬇️ Grab Sample
- ▪️ Rock Core Sample

**NOTES**

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
**MATERIAL DESCRIPTION**

Approximate Elevation: 435.5 ft

- Gray brown, Poorly Graded Gravel with Sand (GP); moist. (Fill)
  - Very loose to loose, gray brown, Sandy Silt (ML); moist; trace roots.
- Loose, gray brown, Silty Sand (SP); moist.
- Loose to dense, gray to brown, Poorly Graded to Well Graded Gravel with Sand (GP) and (GW); wet.

**NOTES**

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
Schist: very low strength, gray brown, schistose, foliated, fissile, gneissose, highly weathered (Birch Creek Schist)

Schist: low to medium strength, gray brown, schistose, gneissose, fissile (Birch Creek Schist)

NOTES
1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
## MATERIAL DESCRIPTION

**Approximate Elevation:** 435.3 ft

<table>
<thead>
<tr>
<th>DEPTH, ft</th>
<th>SYMBOL</th>
<th>SAMPLES</th>
<th>GROUND WATER DEPTH, ft</th>
<th>PENETRATION RESISTANCE (340 lb. weight, 30&quot; drop)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>G-1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.0</td>
<td>S-1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.7</td>
<td>S-2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.3</td>
<td>S-3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.5</td>
<td>S-4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19.5</td>
<td>S-5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28.5</td>
<td>S-6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>S-7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>S-8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Gray-brown, Poorly Graded Sand with Silt and Gravel (SP); wet.**
- **Loose, light gray-brown, Poorly Graded Sand (SP); moist.**
- **Loose, light gray-brown, Poorly Graded Gravel with Sand (GP); wet.**
- **Loose to medium dense, gray-brown, Poorly Graded Gravel with Sand (GP); moist; wet below 12.0 feet.**
- **Loose to medium dense, gray-brown, Poorly Graded Sand with Gravel (SP); wet.**
- **Medium dense to dense, gray-brown, Poorly Graded Sand (SP); wet.**
- **Medium dense, gray-brown, Poorly Graded to Well Graded Gravel with Sand (GP) and (GW); wet.**
  - layer of poorly graded sand with silt from 25.4 to 26.5 feet

### NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
**MATERIAL DESCRIPTION**

Approximate Elevation: 435.3 ft

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>SAMPLES</th>
<th>GROUND WATER DEPTH, ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S-13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S-14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S-15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S-16</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Bottom of Boring
Boring Completed 6/17/2014

- Moderately Weathered Schist Bedrock; medium strength, gray brown; (Birch Creek Schist)

**LEGEND**

- Sample Not Recovered
- 3” O.D. Split Spoon Sample
- Grab Sample
- Rock Core Sample

**NOTES**

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.

University of Alaska Fairbanks
Heat and Power Plant Replacement
Fairbanks, Alaska

**LOG OF BORING 14-07**

2014 31-1-02399-001

SHANNON & WILSON, INC. Geotechnical and Environmental Consultants
Figure A-7 Sheet 2 of 2
**MATERIAL DESCRIPTION**

Approximate Elevation: 435.9 ft

1. Gray-brown, Poorly Graded Gravel with Sand (GP); moist, Fill
2. Gray brown, Sandy Silt with Gravel (ML); moist, Fill
3. Loose, brown, Silty Sand (SM); moist.
4. Loose, gray brown, Sandy Silt (ML); moist.
   - Very loose to loose, light gray-brown, Poorly Graded Sand (SP); moist.
5. Loose to medium dense, interbedded, gray-brown, Poorly Graded Gravel with Sand (GP) and Poorly Graded Sand (SP); moist; wet below 11.0 feet.
   - Very loose to medium dense, gray-brown, Poorly Graded Sand (SP); wet; trace to little gravel.
6. Very loose, gray-brown, Poorly Graded Sand with Gravel (SP); wet.
7. Loose to medium dense, gray-brown, Poorly Graded to Well Graded Gravel with Sand (GP) and (GW); wet.

**NOTES**

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
### MATERIAL DESCRIPTION

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>SAMPLES</th>
<th>GROUND WATER DEPTH, ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-12</td>
<td>40.8</td>
<td>0 10 20 30 40 50</td>
</tr>
<tr>
<td>S-13</td>
<td>48.5</td>
<td>0 10 20 30 40 50</td>
</tr>
<tr>
<td>S-14</td>
<td>76.4</td>
<td>0 10 20 30 40 50</td>
</tr>
<tr>
<td>S-15</td>
<td></td>
<td>50 for 5 inches</td>
</tr>
<tr>
<td>S-16</td>
<td></td>
<td>50 for 5 inches</td>
</tr>
<tr>
<td>S-17</td>
<td></td>
<td>50 for 5 inches</td>
</tr>
<tr>
<td>S-18</td>
<td></td>
<td>50 for 5 inches</td>
</tr>
</tbody>
</table>

**Medium dense, gray-brown, Poorly Graded Sand with Gravel (SP); wet.**

**Medium dense, interbedded, gray-brown, Well Graded Sand with (Silt and) Gravel (SW-SM) and (SW) and Well Graded Gravel with (Silt and) Sand (GW-GM) and (GW); wet.**

**Highly Weathered Schist Bedrock; low strength, gray brown; (Birch Creek Schist)**

---

**NOTES**

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
## MATERIAL DESCRIPTION

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>SAMPLES</th>
<th>GROUND WATER DEPTH, ft</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>81.5</td>
<td>0 10 20 30 40 50</td>
</tr>
</tbody>
</table>

**Bottom of Boring**
Boring Completed 6/12/2014

### LEGEND

- *: Sample Not Recovered
- ▲: Ground Water Level At Time Of Drilling
-<W> : Water Content (%)
- ▲: % Fines (<0.075mm)

### NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
Gray-brown, Silty Sand with Gravel (SM); moist; some schist fragments. Fill

Gray-brown, Silty Sand with Gravel (SM); moist; little schist fragments. Fill

Loose, light gray-brown, interbedded, Poorly Graded Sand (SP) and Silty Sand (SM); moist. Fill

Loose, gray-brown, Sandy Silt with Gravel (ML); moist; little schist fragments. Fill

Loose to medium dense, light gray-brown, interbedded, Sandy Silt (ML) and Silty Sand (SM); moist; wet below 12.0 feet.

- layer of dark brown peat from 8.3 feet to 8.7 feet

Loose, gray-brown, Poorly Graded Sand with Gravel (SP); wet.

Loose, gray-brown, Poorly Graded Sand (SP); wet; little gravel.

Medium dense, gray-brown, Well Graded Gravel with Sand (GW); wet.

**NOTES**

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
### MATERIAL DESCRIPTION

Approximate Elevation: 434.6 ft

<table>
<thead>
<tr>
<th>DEPTH, ft</th>
<th>SYMBOL</th>
<th>SAMPLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td></td>
<td>G-1</td>
</tr>
<tr>
<td>2.0</td>
<td></td>
<td>S-1</td>
</tr>
<tr>
<td>7.0</td>
<td></td>
<td>S-2</td>
</tr>
<tr>
<td>8.0</td>
<td></td>
<td>S-3</td>
</tr>
<tr>
<td>9.5</td>
<td></td>
<td>S-4</td>
</tr>
<tr>
<td>12.0</td>
<td></td>
<td>S-5</td>
</tr>
<tr>
<td>16.5</td>
<td></td>
<td>S-6</td>
</tr>
</tbody>
</table>

- Gray-brown, Silty Sand with Gravel (SM); moist. Fill
- Loose, light gray-brown, Poorly Graded Sand (SP); moist. - trace wood fragments from 4.5 feet to 7.0 feet
- Light gray-brown, Poorly Graded Gravel with Sand (GP); moist.
- Loose, light gray-brown, Poorly Graded Sand (SP); moist. - trace wood fragments from 4.5 feet to 7.0 feet
- Loose, gray-brown, Poorly Graded Sand with Gravel (SP); moist to very moist below 11.2 feet.
- Loose, gray-brown, Poorly Graded Sand (SP); wet; trace gravel. Bottom of Boring

**NOTES**

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.

**LEGEND**

- Sample Not Recovered
- 3" O.D. Split Spoon Sample
- Grab Sample
- Rock Core Sample
- Water Content (%)
- % Fines (<0.075mm)
- Ground Water Level At Time Of Drilling
- Boring Completed 6/6/2014
Gray-brown, Poorly Graded Sand with Gravel (SP); Moist. Fill
Loose to medium dense, interbedded, light gray-brown to gray-brown, interbedded, Sandy Silt (ML) and Silty Sand (SM); moist.

Loose, light gray-brown, Poorly Graded Sand (SP); moist.
Loose to medium dense, gray-brown, Poorly Graded Gravel with Sand (GP); moist; wet below 12.0 feet.

**NOTES**
1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
### MATERIAL DESCRIPTION

Approximate Elevation: 436.6 ft

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>SAMPLES</th>
<th>DEPTH, ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>G-1</td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>S-1</td>
<td></td>
<td>2.8</td>
</tr>
<tr>
<td>S-2</td>
<td></td>
<td>3.2</td>
</tr>
<tr>
<td>S-3</td>
<td></td>
<td>4.5</td>
</tr>
<tr>
<td>S-4</td>
<td></td>
<td>8.2</td>
</tr>
<tr>
<td>S-5</td>
<td></td>
<td>9.5</td>
</tr>
<tr>
<td>S-6</td>
<td></td>
<td>12.0</td>
</tr>
<tr>
<td>~</td>
<td></td>
<td>16.5</td>
</tr>
</tbody>
</table>

**Dark brown, Poorly Graded Gravel with Sand (GP):** moist. Fill

**Brown, Silty Sand with Gravel (SM):** moist. Fill

**Loose, brown, Poorly Graded Sand with Silt (SP-SM):** moist.

**Loose, brown, Silt with Sand (ML):** moist.

**Loose to medium dense, gray-brown, Poorly Graded Sand (SP):** wet; trace gravel.

**Loose, light gray-brown, Poorly Graded Gravel with Sand (GP):** moist.

**Loose, light gray-brown, Poorly Graded Sand (SP):** moist.

**Medium dense, gray-brown, Poorly Graded Gravel with Sand (GP):** wet.

---

**NOTES**

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.

---

**LEGEND**

- * Sample Not Recovered
- ** Sample Recovered
- 3" O.D. Split Spoon Sample
- Grab Sample
- Rock Core Sample

**Univeristy of Alaska Fairbanks**

Heat and Power Plant Replacement
Fairbanks, Alaska

**LOG OF BORING 14-12**

2014 31-1-02399-001
The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.

Bottom of Boring
Boring Completed 6/6/2014

Approximate Elevation: 436.4 ft

<table>
<thead>
<tr>
<th>DEPTH, ft</th>
<th>SYMBOL</th>
<th>SAMPLES</th>
<th>PID (ppm)</th>
<th>GROUND WATER</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LEGEND

* Sample Not Recovered
# 3" O.D. Split Spoon Sample
√ Grab Sample
□ Rock Core Sample
■ Frozen

Water Content (%)

% Fines (<0.075mm)

Ground Water Level At Time Of Drilling

Penetration Resistance
(340 lb. weight, 30" drop)
△ Blows per foot

Univeristy of Alaska Fairbanks
Heat and Power Plant Replacement
Fairbanks, Alaska

LOG OF BORING 14-13

2014
31-1-02399-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Figure A-13
**MATERIAL DESCRIPTION**

Approximate Elevation: 439.4 ft

<table>
<thead>
<tr>
<th>DEPTH, ft</th>
<th>SYMBOL</th>
<th>SAMPLES</th>
<th>PID (rpm)</th>
<th>GROUND WATER</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td></td>
<td>0-1</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td></td>
<td>0-2</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>10.4</td>
<td></td>
<td>0-3</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>12.9</td>
<td></td>
<td>0-4</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>14.5</td>
<td></td>
<td>0-5</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>16.5</td>
<td></td>
<td>0-6</td>
<td>0.0</td>
<td></td>
</tr>
</tbody>
</table>

Gray-brown, Poorly Graded Gravel with Silt and Sand (GP); moist. Fill

Loose to medium dense, gray-brown, Silty Sand with Gravel (SM); moist; frozen Nf from 7.5 feet to 8.0 feet. Fill

Loose, gray, Silty Sand (SM); moist to very moist.
- black wood fragments from 10.4 feet to 10.7 feet
grey brown, Sandy Silt (ML); very moist.
- sand layer from 13.6 feet to 13.9 feet
Loose, gray, Poorly Graded Sand with Silt (SP-SM); wet; trace gravel; trace wood fragments.

**NOTES**

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.

**LEGEND**

- Sample Not Recovered
- 3” O.D. Split Spoon Sample
- Grab Sample
- Rock Core Sample
- Frozen

**Ground Water Level at Time Of Drilling**

- Water Content (%)
- % Fines (<0.075mm)

**Univeristy of Alaska Fairbanks**
Heat and Power Plant Replacement
Fairbanks, Alaska

**LOG OF BORING 14-14**

2014 31-1-02399-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Figure A-14
APPENDIX B

LABORATORY TEST RESULTS
APPENDIX B

LABORATORY TEST RESULTS

TABLE OF CONTENTS

FIGURES

B-1 Grain Size Distribution Boring 14-01
B-2 Grain Size Distribution Boring 14-02 (2 sheets)
B-3 Grain Size Distribution Boring 14-03 (2 sheets)
B-4 Grain Size Distribution Boring 14-04 (2 sheets)
B-5 Grain Size Distribution Boring 14-05 (2 sheets)
B-6 Grain Size Distribution Boring 14-06 (2 sheets)
B-7 Grain Size Distribution Boring 14-07 (2 sheets)
B-8 Grain Size Distribution Boring 14-08 (3 sheets)
B-9 Grain Size Distribution Boring 14-09
B-10 Grain Size Distribution Boring 14-10
B-11 Grain Size Distribution Boring 14-11
B-12 Grain Size Distribution Boring 14-12
B-13 Grain Size Distribution Boring 14-13
B-14 Grain Size Distribution Boring 14-14
### Sieve Analysis

<table>
<thead>
<tr>
<th>Size of Mesh Opening in Inches</th>
<th>No. of Mesh Openings per Inch, U.S. Standard</th>
<th>Grain Size in Millimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>100</td>
<td>0.01</td>
</tr>
<tr>
<td>90</td>
<td>90</td>
<td>0.02</td>
</tr>
<tr>
<td>80</td>
<td>80</td>
<td>0.03</td>
</tr>
<tr>
<td>70</td>
<td>70</td>
<td>0.04</td>
</tr>
<tr>
<td>60</td>
<td>60</td>
<td>0.05</td>
</tr>
<tr>
<td>50</td>
<td>50</td>
<td>0.06</td>
</tr>
<tr>
<td>40</td>
<td>40</td>
<td>0.07</td>
</tr>
<tr>
<td>30</td>
<td>30</td>
<td>0.08</td>
</tr>
<tr>
<td>20</td>
<td>20</td>
<td>0.09</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>0.10</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>0.20</td>
</tr>
</tbody>
</table>

### Hydrometer Analysis

**Legend**

- **USCS:** Unified Soil Classification System
- **Cobble REM %:** Percentage of cobbles removed from specimen based on pre-removal total dry mass
- **< 2 μm %:** Percentage of soil particles finer than 2 micrometers (0.002 mm); clay-size fraction
- **NAT WC %:** Natural water content
  - Cu: Coefficient of uniformity
  - Cc: Coefficient of curvature
- **ASTM DES:** ASTM International test standard designation

### Soil Classification

- **Boring and Sample No.:** 14-02, S-11
- **Depth (feet):** 35.0
- **USCS Symbol:** GP
- **Soil Classification:** Poorly graded gravel with sand

<table>
<thead>
<tr>
<th>Gravel %</th>
<th>Sand %</th>
<th>Finer than 2 μm %</th>
<th>Coarse Rem %</th>
<th>NAT WC %</th>
<th>Cu</th>
<th>Cc</th>
<th>Test By</th>
<th>Review By</th>
<th>ASTM DES</th>
</tr>
</thead>
<tbody>
<tr>
<td>49</td>
<td>49</td>
<td>2.1</td>
<td>24.4</td>
<td>0.7</td>
<td>AMV</td>
<td>AMV</td>
<td>C136</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Sieve Analysis

<table>
<thead>
<tr>
<th>Size of Mesh Opening in Inches</th>
<th>No. of Mesh Openings per Inch U.S. Standard</th>
<th>Grain Size in Millimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.001</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>0.002</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>0.003</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>0.004</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>0.006</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>0.01</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>0.02</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>0.03</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>0.04</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>0.06</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>0.1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>0.2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>0.3</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

### Hydrometer Analysis

- **USCS:** Unified Soil Classification System
- **COBBLE REM %:** Percentage of cobbles removed from specimen, based on pre-removal total dry mass
- **< 2 µm %:** Percentage of soil particles finer than 2 micrometers (0.002 mm); clay-size fraction
- **NAT WC %:** Natural water content
- **Cu:** Coefficient of uniformity
- **Cc:** Coefficient of curvature
- **ASTM DES:** ASTM International test standard designation

### Soil Classification

- **GP** Poorly graded gravel with sand

### Grain Size Distribution

**Boring 14-03**

**University of Alaska Fairbanks**

Heat and Power Plant Replacement

Fairbanks, Alaska

**Grain Size Distribution Boring 14-03**

2014 31-1-02399-001

**Amendment No. 5**

**SHANNON & WILSON, INC.**

Geotechnical and Environmental Consultants

Design Alaska, Inc.

**FIG. B-3** Sheet 2 of 2
**SIEVE ANALYSIS**

<table>
<thead>
<tr>
<th>SIZE OF MESH OPENING IN INCHES</th>
<th>NO. OF MESH OPENINGS PER INCH, U.S. STANDARD</th>
<th>GRAIN SIZE IN MILLIMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>90</td>
<td>20</td>
<td>0.01</td>
</tr>
<tr>
<td>80</td>
<td>40</td>
<td>0.002</td>
</tr>
<tr>
<td>70</td>
<td>80</td>
<td>0.004</td>
</tr>
<tr>
<td>60</td>
<td>100</td>
<td>0.008</td>
</tr>
<tr>
<td>50</td>
<td>200</td>
<td>0.012</td>
</tr>
<tr>
<td>40</td>
<td>400</td>
<td>0.016</td>
</tr>
<tr>
<td>30</td>
<td>600</td>
<td>0.02</td>
</tr>
<tr>
<td>20</td>
<td>800</td>
<td>0.04</td>
</tr>
<tr>
<td>10</td>
<td>1000</td>
<td>0.08</td>
</tr>
</tbody>
</table>

**COARSE**

- 1/2
- 3/8
- 4

**FINE**

- 1
- 3/4
- 60

**FINES: SILT OR CLAY**

- 200
- 0.06
- 0.02

**PERCENT COARSER BY WEIGHT**

<table>
<thead>
<tr>
<th>DEPTH (feet)</th>
<th>USCS SYMBOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.0</td>
<td>SP</td>
</tr>
<tr>
<td>12.5</td>
<td>GW</td>
</tr>
<tr>
<td>15.0</td>
<td>SP</td>
</tr>
<tr>
<td>17.5</td>
<td>GW</td>
</tr>
<tr>
<td>20.0</td>
<td>GP</td>
</tr>
<tr>
<td>25.0</td>
<td>GW</td>
</tr>
<tr>
<td>30.0</td>
<td>GP</td>
</tr>
</tbody>
</table>

**SOIL CLASSIFICATION**

- Poorly graded sand with gravel
- Well-graded gravel with sand
- Poorly graded sand with gravel
- Well-graded gravel with sand
- Poorly graded gravel with sand
- Well-graded gravel with sand
- Poorly graded gravel with sand
- Well-graded gravel with sand

**PERCENT FINER BY WEIGHT**

<table>
<thead>
<tr>
<th>DEPTH (feet)</th>
<th>USCS SYMBOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.0</td>
<td>SP</td>
</tr>
<tr>
<td>12.5</td>
<td>GW</td>
</tr>
<tr>
<td>15.0</td>
<td>SP</td>
</tr>
<tr>
<td>17.5</td>
<td>GW</td>
</tr>
<tr>
<td>20.0</td>
<td>GP</td>
</tr>
<tr>
<td>25.0</td>
<td>GW</td>
</tr>
<tr>
<td>30.0</td>
<td>GP</td>
</tr>
</tbody>
</table>

**PRE-REMoval toal Dry Mass**

<table>
<thead>
<tr>
<th>DEPTH (feet)</th>
<th>USCS SYMBOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.0</td>
<td>SP</td>
</tr>
<tr>
<td>12.5</td>
<td>GW</td>
</tr>
<tr>
<td>15.0</td>
<td>SP</td>
</tr>
<tr>
<td>17.5</td>
<td>GW</td>
</tr>
<tr>
<td>20.0</td>
<td>GP</td>
</tr>
<tr>
<td>25.0</td>
<td>GW</td>
</tr>
<tr>
<td>30.0</td>
<td>GP</td>
</tr>
</tbody>
</table>

**COEFFICIENT OF UNIFORMITY (Cu)**

<table>
<thead>
<tr>
<th>DEPTH (feet)</th>
<th>USCS SYMBOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.0</td>
<td>SP</td>
</tr>
<tr>
<td>12.5</td>
<td>GW</td>
</tr>
<tr>
<td>15.0</td>
<td>SP</td>
</tr>
<tr>
<td>17.5</td>
<td>GW</td>
</tr>
<tr>
<td>20.0</td>
<td>GP</td>
</tr>
<tr>
<td>25.0</td>
<td>GW</td>
</tr>
<tr>
<td>30.0</td>
<td>GP</td>
</tr>
</tbody>
</table>

**COEFFICIENT OF CURVATURE (Cc)**

<table>
<thead>
<tr>
<th>DEPTH (feet)</th>
<th>USCS SYMBOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.0</td>
<td>SP</td>
</tr>
<tr>
<td>12.5</td>
<td>GW</td>
</tr>
<tr>
<td>15.0</td>
<td>SP</td>
</tr>
<tr>
<td>17.5</td>
<td>GW</td>
</tr>
<tr>
<td>20.0</td>
<td>GP</td>
</tr>
<tr>
<td>25.0</td>
<td>GW</td>
</tr>
<tr>
<td>30.0</td>
<td>GP</td>
</tr>
</tbody>
</table>

**ASTM INTERNATIONAL DESIGNATION**

- C136

---

**LEGEND**

- USCS: Unified Soil Classification System
- COBBLE REM %: Percentage of cobbles removed from specimen, based on pre-removal total dry mass
- < 2 μm %: Percentage of soil particles finer than 2 micrometers (0.002 mm); clay-size fraction
- NAT WC %: Natural water content
- Cu: Coefficient of uniformity
- Cc: Coefficient of curvature
- ASTM DES: ASTM International test standard designation
### Grave Size Distribution

#### Boring 14-05

<table>
<thead>
<tr>
<th>Boring and Sample No.</th>
<th>Depth (feet)</th>
<th>USCS Symbol</th>
<th>Soil Classification</th>
<th>Gravel %</th>
<th>Sand %</th>
<th>Finer %</th>
<th>Cobble Rem %</th>
<th>&lt;2 μm %</th>
<th>Nat WC %</th>
<th>Cu</th>
<th>Cc</th>
<th>Test By</th>
<th>Review By</th>
<th>ASTM Des</th>
</tr>
</thead>
<tbody>
<tr>
<td>14-05, S-11</td>
<td>35.0</td>
<td>GP</td>
<td>Poorly graded gravel with sand</td>
<td>49</td>
<td>48</td>
<td>2.3</td>
<td>0.4 AMV</td>
<td>23.3</td>
<td>0.4</td>
<td>AMV</td>
<td>AMV</td>
<td>C136</td>
<td>C136</td>
<td></td>
</tr>
<tr>
<td>14-05, S-12</td>
<td>40.0</td>
<td>GW</td>
<td>Well graded gravel with sand</td>
<td>57</td>
<td>39</td>
<td>4.9</td>
<td>2.9 AMV</td>
<td>24.2</td>
<td>2.9</td>
<td>AMV</td>
<td>AMV</td>
<td>C136</td>
<td>C136</td>
<td></td>
</tr>
</tbody>
</table>

**Legend**

- **USCS:** Unified Soil Classification System
- **COBBLE REM %:** Percentage of cobbles removed from specimen; based on pre-removal total dry mass
- **< 2 μm %:** Percentage of soil particles finer than 2 micrometers (0.002 mm); clay-size fraction
- **NAT WC %:** Natural water content
- **Cu:** Coefficient of uniformity
- **Cc:** Coefficient of curvature
- **ASTM DES:** ASTM International test standard designation

**University of Alaska Fairbanks**

Heat and Power Plant Replacement
Fairbanks, Alaska

**Grain Size Distribution**

Boring 14-05

2014

31-1-02399-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants
Design Alaska, Inc.
**LEGEND**

USCS: Unified Soil Classification System

COBBLE REM %: Percentage of cobbles removed from specimen, based on pre-removal total dry mass

< 2 μm %: Percentage of soil particles finer than 2 micrometers (0.002 mm); clay-size fraction

NAT WC %: Natural water content

Cu: Coefficient of uniformity

Cc: Coefficient of curvature

ASTM DES: ASTM International test standard designation
### Sieve Analysis

- **Size of Mesh Opening in Inches**
- **No. of Mesh Openings Per Inch, U.S. Standard**
- **Grain Size in Millimeters**

### Hydrometer Analysis

- **Gravel**
- **Sand**

---

**Legend**

- **USCS:** Unified Soil Classification System
- **COBBLE REM %:** Percentage of cobbles removed from specimen, based on pre-removal total dry mass
- **< 2 μm %:** Percentage of soil particles finer than 2 micrometers (0.002 mm); clay-size fraction
- **NAT WC %:** Natural water content
- **Cu:** Coefficient of uniformity
- **Cc:** Coefficient of curvature
- **ASTM DES:** ASTM International test standard designation

---

**Soil Classification**

- **14-07, S-4**
  - Depth: 10.0 feet
  - USCS Symbol: GP
  - Soil: Poorly graded gravel with sand
  - Gravel %: 50
  - Sand %: 48
  - Finer %: 2.5
  - Cobble Rem %: 5.4
  - < 2 μm %: 35.6
  - NAT WC %: 0.1
  - Cu: AMV
  - Cc: AMV
  - ASTM DES: C136
- **14-07, S-5**
  - Depth: 12.5 feet
  - USCS Symbol: GW
  - Soil: Well-graded gravel with sand
  - Gravel %: 54
  - Sand %: 43
  - Finer %: 2.3
  - Cobble Rem %: 32.6
  - < 2 μm %: 2.4
  - NAT WC %: AMV
  - Cu: AMV
  - Cc: AMV
  - ASTM DES: C136
- **14-07, S-6**
  - Depth: 15.0 feet
  - USCS Symbol: SP
  - Soil: Poorly graded sand with gravel
  - Gravel %: 27
  - Sand %: 70
  - Finer %: 3.0
  - Cobble Rem %: 3.7
  - < 2 μm %: 0.8
  - NAT WC %: AMV
  - Cu: AMV
  - Cc: AMV
  - ASTM DES: C136
- **14-07, S-7**
  - Depth: 17.5 feet
  - USCS Symbol: SP
  - Soil: Poorly graded sand with gravel
  - Gravel %: 28
  - Sand %: 70
  - Finer %: 2.2
  - Cobble Rem %: 13.9
  - < 2 μm %: 0.2
  - NAT WC %: AMV
  - Cu: AMV
  - Cc: AMV
  - ASTM DES: C136
- **14-07, S-8**
  - Depth: 20.0 feet
  - USCS Symbol: GW
  - Soil: Well-graded gravel with sand
  - Gravel %: 52
  - Sand %: 44
  - Finer %: 4.0
  - Cobble Rem %: 46.2
  - < 2 μm %: 1.9
  - NAT WC %: AMV
  - Cu: AMV
  - Cc: AMV
  - ASTM DES: C136
- **14-07, S-9**
  - Depth: 25.0 feet
  - USCS Symbol: SP
  - Soil: Poorly graded sand
  - Gravel %: 97
  - Sand %: 2.6
  - Finer %: 1.9
  - Cobble Rem %: 1.9
  - < 2 μm %: 1.1
  - NAT WC %: AMV
  - Cu: AMV
  - Cc: AMV
  - ASTM DES: C136
- **14-07, S-10**
  - Depth: 30.0 feet
  - USCS Symbol: GP
  - Soil: Poorly graded gravel with sand
  - Gravel %: 57
  - Sand %: 42
  - Finer %: 1.9
  - Cobble Rem %: 32.1
  - < 2 μm %: 0.5
  - NAT WC %: AMV
  - Cu: AMV
  - Cc: AMV
  - ASTM DES: C136

---

University of Alaska Fairbanks
Heat and Power Plant Replacement
Fairbanks, Alaska

**Grain Size Distribution**

**Boring 14-07**

2014

**Design Alaska, Inc.**

**Shannon & Wilson, Inc.**

**FIG. B-7**

Sheet 1 of 2
Sieve Analysis

<table>
<thead>
<tr>
<th>Size of Mesh Opening in Inches</th>
<th>No. of Mesh Openings Per Inch, U.S. Standard</th>
<th>Grain Size in Millimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>10</td>
<td>76.2</td>
</tr>
<tr>
<td>3/8</td>
<td>15</td>
<td>60</td>
</tr>
<tr>
<td>1/4</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>3/16</td>
<td>60</td>
<td>20</td>
</tr>
<tr>
<td>1/8</td>
<td>100</td>
<td>10</td>
</tr>
</tbody>
</table>

Hydrometer Analysis

<table>
<thead>
<tr>
<th>USCS/Symbol</th>
<th>Gravel %</th>
<th>Sand %</th>
<th>Finer %</th>
<th>Cobble Rem %</th>
<th>Coefficient of Uniformity</th>
<th>Coefficient of Curvature</th>
<th>Test By</th>
<th>Review By</th>
<th>ASTM Des</th>
</tr>
</thead>
<tbody>
<tr>
<td>GW</td>
<td>58</td>
<td>39</td>
<td>2.5</td>
<td></td>
<td>24.4</td>
<td>2.6</td>
<td>AMV</td>
<td>AMV</td>
<td>C136</td>
</tr>
<tr>
<td>GW</td>
<td>59</td>
<td>39</td>
<td>1.7</td>
<td></td>
<td>32.0</td>
<td>1.2</td>
<td>AMV</td>
<td>AMV</td>
<td>C136</td>
</tr>
<tr>
<td>SP-SM</td>
<td>4</td>
<td>90</td>
<td>6.4</td>
<td></td>
<td>2.6</td>
<td>1.2</td>
<td>AMV</td>
<td>AMV</td>
<td>C136</td>
</tr>
<tr>
<td>GP</td>
<td>54</td>
<td>42</td>
<td>3.6</td>
<td></td>
<td>40.5</td>
<td>0.4</td>
<td>AMV</td>
<td>AMV</td>
<td>C136</td>
</tr>
<tr>
<td>GW-GM</td>
<td>53</td>
<td>41</td>
<td>5.7</td>
<td></td>
<td>49.9</td>
<td>1.0</td>
<td>AMV</td>
<td>AMV</td>
<td>C136</td>
</tr>
</tbody>
</table>

Legend

- **USCS**: Unified Soil Classification System
- **Cobble Rem %**: Percentage of cobbles removed from specimen, based on pre-removal total dry mass
- **< 2 μm %**: Percentage of soil particles finer than 2 micrometers (0.002 mm); clay-size fraction
- **NAT WC %**: Natural water content
- **Cu**: Coefficient of uniformity
- **Cc**: Coefficient of curvature
- **ASTM Des**: ASTM International test standard designation

**University of Alaska Fairbanks**

Heat and Power Plant Replacement

Fairbanks, Alaska

**GRAIN SIZE DISTRIBUTION**

**BORING 14-07**

2014

**SHANNON & WILSON, INC.**

Geotechnical and Environmental Consultants

**Design Alaska, Inc.**
### SIEVE ANALYSIS

<table>
<thead>
<tr>
<th>GRAIN SIZE IN MILLIMETERS</th>
<th>NO. OF MESH OPENINGS PER INCH, U.S. STANDARD</th>
</tr>
</thead>
</table>

### HYDROMETER ANALYSIS

<table>
<thead>
<tr>
<th>GRAIN SIZE IN MILLIMETERS</th>
<th>PERCENT COARSEER BY WEIGHT</th>
<th>PERCENT FINER BY WEIGHT</th>
</tr>
</thead>
</table>

#### LEGEND

- **USCS:** Unified Soil Classification System
- **COBBLE REM %:** Percentage of cobbles removed from specimen, based on pre-removal total dry mass
- **< 2 µm %:** Percentage of soil particles finer than 2 micrometers (0.002 mm); clay-size fraction
- **NAT WC %:** Natural water content
- **Cu:** Coefficient of uniformity
- **Cc:** Coefficient of curvature
- **ASTM DES:** ASTM International test standard designation

---

**Univeristy of Alaska Fairbanks**

**Heat and Power Plant Replacement**

**Fairbanks, Alaska**

**GRAIN SIZE DISTRIBUTION**

**BORING 14-08**

2014

**SHANNON & WILSON, INC.**

Geotechnical and Environmental Consultants

Design Alaska, Inc.
### Sieve Analysis

<table>
<thead>
<tr>
<th>Size of Mesh Opening in Inches</th>
<th>No. of Mesh Openings per Inch, U.S. Standard</th>
<th>Grain Size in Millimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td>17/32</td>
<td>36</td>
<td>1.1</td>
</tr>
<tr>
<td>1/8</td>
<td>56</td>
<td>3.2</td>
</tr>
<tr>
<td>3/32</td>
<td>90</td>
<td>4.8</td>
</tr>
<tr>
<td>1/16</td>
<td>180</td>
<td>9.6</td>
</tr>
<tr>
<td>3/64</td>
<td>360</td>
<td>19.2</td>
</tr>
<tr>
<td>1/32</td>
<td>720</td>
<td>38.4</td>
</tr>
</tbody>
</table>

### Hydrometer Analysis

- **USCS**: Unified Soil Classification System
- **Cobble REM %**: Percentage of cobbles removed from specimen, based on pre-removal total dry mass
- **< 2 um %**: Percentage of soil particles finer than 2 micrometers (0.002 mm); clay-size fraction
- **NAT WC %**: Natural water content
- **Cu**: Coefficient of uniformity
- **Cc**: Coefficient of curvature
- **ASTM DES**: ASTM International test standard designation

### Legend

- **COARSE**: Sand with gravel
- **FINE**: Silt or clay
- **COBBLE REM %**: Percentage of cobbles removed from specimen, based on pre-removal total dry mass
- **< 2 um %**: Percentage of soil particles finer than 2 micrometers (0.002 mm); clay-size fraction
- **NAT WC %**: Natural water content
- **Cu**: Coefficient of uniformity
- **Cc**: Coefficient of curvature
- **ASTM DES**: ASTM International test standard designation
### Sieve Analysis

<table>
<thead>
<tr>
<th>Size of Mesh Opening in Inches</th>
<th>No. of Mesh Openings Per Inch, U.S. Standard</th>
<th>Grain Size in Millimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>1/2</td>
<td>0.01</td>
</tr>
<tr>
<td>90</td>
<td>3/4</td>
<td>0.002</td>
</tr>
<tr>
<td>80</td>
<td>1/4</td>
<td>0.004</td>
</tr>
<tr>
<td>70</td>
<td>1/8</td>
<td>0.006</td>
</tr>
<tr>
<td>60</td>
<td>3/8</td>
<td>0.008</td>
</tr>
<tr>
<td>50</td>
<td>1/16</td>
<td>0.010</td>
</tr>
<tr>
<td>40</td>
<td>1/32</td>
<td>0.013</td>
</tr>
<tr>
<td>30</td>
<td>1/64</td>
<td>0.015</td>
</tr>
<tr>
<td>20</td>
<td>1/96</td>
<td>0.018</td>
</tr>
<tr>
<td>10</td>
<td>1/192</td>
<td>0.020</td>
</tr>
<tr>
<td>5</td>
<td>1/384</td>
<td>0.025</td>
</tr>
</tbody>
</table>

### Grainsize Distribution

<table>
<thead>
<tr>
<th>Boring and Sample No.</th>
<th>Depth (feet)</th>
<th>USCS Symbol</th>
<th>Soil Classification</th>
<th>Gravel %</th>
<th>Sand %</th>
<th>Finer than 2 mm %</th>
<th>Cobble Rem %</th>
<th>NAT WC %</th>
<th>Cu</th>
<th>Cc</th>
<th>Test By</th>
<th>Review By</th>
<th>ASTM Des</th>
</tr>
</thead>
<tbody>
<tr>
<td>14-08, S-18</td>
<td>75.0</td>
<td>GW-GM</td>
<td>Well-graded gravel with silt and sand</td>
<td>59</td>
<td>36</td>
<td>5.3</td>
<td>68.9</td>
<td>2.3</td>
<td>AMV</td>
<td>AMV</td>
<td>C136</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Legend

- **USCS**: Unified Soil Classification System
- **COBBLE REM %**: Percentage of cobbles removed from specimen, based on pre-removal total dry mass
- **< 2 μm %**: Percentage of soil particles finer than 2 micrometers (0.002 mm); clay-size fraction
- **NAT WC %**: Natural water content
  - **Cu**: Coefficient of uniformity
  - **Cc**: Coefficient of curvature
- **ASTM DES**: ASTM International test standard designation

---

**Univeristy of Alaska Fairbanks**
Heat and Power Plant Replacement
Fairbanks, Alaska

**GRAIN SIZE DISTRIBUTION**
BORING 14-08

2014 31-1-02399-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants
Design Alaska, Inc.
**Sieve Analysis**

<table>
<thead>
<tr>
<th>Size of Mesh Opening in Inches</th>
<th>No. of Mesh Openings Per Inch, U.S. Standard</th>
<th>Grain Size in Millimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0.01</td>
<td>0.001</td>
</tr>
<tr>
<td>8</td>
<td>0.02</td>
<td>0.002</td>
</tr>
<tr>
<td>6</td>
<td>0.03</td>
<td>0.003</td>
</tr>
<tr>
<td>3</td>
<td>0.04</td>
<td>0.004</td>
</tr>
<tr>
<td>2</td>
<td>0.06</td>
<td>0.006</td>
</tr>
<tr>
<td>1</td>
<td>0.10</td>
<td>0.010</td>
</tr>
<tr>
<td>0.5</td>
<td>0.20</td>
<td>0.020</td>
</tr>
<tr>
<td>0.25</td>
<td>0.40</td>
<td>0.040</td>
</tr>
<tr>
<td>0.15</td>
<td>0.60</td>
<td>0.060</td>
</tr>
<tr>
<td>0.10</td>
<td>1.00</td>
<td>0.100</td>
</tr>
</tbody>
</table>

**Hydrometer Analysis**

- **USCS**: Unified Soil Classification System
- **Cobble Rem %**: Percentage of cobbles removed from specimen; based on pre-removal total dry mass
- **< 2 μm %**: Percentage of soil particles finer than 2 micrometers (0.002 mm); clay-size fraction
- **NAT WC %**: Natural water content
  - **Cu**: Coefficient of uniformity
  - **Cc**: Coefficient of curvature
- **ASTM DES**: ASTM International test standard designation

**Legend**

**SOIL CLASSIFICATION**

- **Coarse**: gravel
- **Medium**: sand
- **Fine**: silt or clay

**Results**

- **14-09, S-1**
  - Depth: 2.5 feet
  - USCS Symbol: SM
  - Soil Type: Silty sand
  - Gravel %: 13
  - Sand %: 50
  - Finer %: 37.7
  - Cobble Rem %: 37.7
  - < 2 μm %: 3.7
  - NAT WC %: 12.5
  - Cu: 2.3
  -Cc: 1.1
  - ASTM DES: AMV AMV C136

- **14-09, S-5**
  - Depth: 12.5 feet
  - USCS Symbol: SP
  - Soil Type: Poorly graded sand
  - Gravel %: 14
  - Sand %: 83
  - Finer %: 2.5
  - Cobble Rem %: 2.5
  - < 2 μm %: 0.5
  - NAT WC %: 2.3
  - Cu: 1.1
  - Cc: 0.4
  - ASTM DES: AMV AMV C136

- **14-09, S-6**
  - Depth: 15.0 feet
  - USCS Symbol: GW
  - Soil Type: Well graded gravel with sand
  - Gravel %: 55
  - Sand %: 42
  - Finer %: 2.6
  - Cobble Rem %: 2.6
  - < 2 μm %: 0.6
  - NAT WC %: 34.2
  - Cu: 0.4
  - Cc: 0.4
  - ASTM DES: AMV AMV C136

**University of Alaska Fairbanks**

Heat and Power Plant Replacement
Fairbanks, Alaska

**Graould Size Distribution**

**Boring 14-09**

2014

31-1-02399-001

Shannon & Wilson, Inc. (Geotechnical and Environmental Consultants)

Design Alaska, Inc.
LEGEND

USCS: Unified Soil Classification System

COBBLE REM %: Percentage of cobbles removed from specimen; based on pre-removal total dry mass

< 2 μm %: Percentage of soil particles finer than 2 micrometers (0.002 mm); clay-size fraction

NAT WC %: Natural water content

Cu: Coefficient of uniformity

Cc: Coefficient of curvature

ASTM DES: ASTM International test standard designation

### Data

- **BORING** 14-10
- **DEPTH** 5.0 feet
- **USCS SYMBOL** SP
- **SOIL CLASSIFICATION** Poorly graded sand
- **SIEVE ANALYSIS**
  - **PERCENT FINER BY WEIGHT**
  - **PERCENT COARSER BY WEIGHT**

- **HYDROMETER ANALYSIS**
  - **GRAVEL**
  - **SAND**

- **LEGEND**
  - **COARSE**
  - **FINE**
  - **COARSE**
  - **MEDIUM**
  - **FINE**
  - **FINES: SILT OR CLAY**

### Notes

- **University of Alaska Fairbanks**
- **Heat and Power Plant Replacement**
- **Fairbanks, Alaska**

### Report

- **Design Alaska, Inc.**
- **Structural Geotechnical and Environmental Consultants**

### Graphical Information

- **G R A I N  S I Z E  D I S T R I B U T I O N**
  - **B O R I N G  1 4 - 1 0**

### Publications

- **RFP No. 15P0015MG - Air-Cooled Condensing System**
- **Amendment No. 5**

### Additional Information

- **DocuSign Envelope ID:** D6847BF8-75A1-4084-882F-CE473BA93EE
### GRAIN SIZE DISTRIBUTION

**BORING 14-11**

<table>
<thead>
<tr>
<th>BORING AND SAMPLE NO.</th>
<th>DEPTH (feet)</th>
<th>USCS SYMBOL</th>
<th>SOIL CLASSIFICATION</th>
<th>GRAVEL %</th>
<th>SAND %</th>
<th>FINES %</th>
<th>COBBLE REM %</th>
<th>&lt; 2 ( \mu \text{m} ) %</th>
<th>NAT WC %</th>
<th>Cu</th>
<th>Cc</th>
<th>TEST BY</th>
<th>REVIEW BY</th>
<th>ASTM DES</th>
</tr>
</thead>
<tbody>
<tr>
<td>14-11, S-2</td>
<td>5.0</td>
<td>ML</td>
<td>Silt with sand</td>
<td>29</td>
<td>71.2</td>
<td>0</td>
<td>11.0</td>
<td>31-1-02399-001</td>
<td>AMV</td>
<td>AMV</td>
<td>C136</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Univeristy of Alaska Fairbanks**  
Heat and Power Plant Replacement  
Fairbanks, Alaska

**GRAIN SIZE IN MILLIMETERS**

**LEGEND**

- **USCS:** Unified Soil Classification System
- **COBBLE REM %:** Percentage of cobbles removed from specimen; based on pre-removal total dry mass
- **< 2 \( \mu \text{m} \) %:** Percentage of soil particles finer than 2 micrometers (0.002 mm); clay-size fraction
- **NAT WC %:** Natural water content
- **Cu:** Coefficient of uniformity
- **Cc:** Coefficient of curvature
- **ASTM DES:** ASTM International test standard designation
# Sieve Analysis

<table>
<thead>
<tr>
<th>Size of Mesh Opening in Inches</th>
<th>No. of Mesh Openings per Inch, U.S. Standard</th>
<th>Grain Size in Millimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>100</td>
<td>0.01</td>
</tr>
<tr>
<td>90</td>
<td>90</td>
<td>0.002</td>
</tr>
<tr>
<td>80</td>
<td>80</td>
<td>0.004</td>
</tr>
<tr>
<td>70</td>
<td>70</td>
<td>0.006</td>
</tr>
<tr>
<td>60</td>
<td>60</td>
<td>0.008</td>
</tr>
<tr>
<td>50</td>
<td>50</td>
<td>0.010</td>
</tr>
<tr>
<td>40</td>
<td>40</td>
<td>0.012</td>
</tr>
<tr>
<td>30</td>
<td>30</td>
<td>0.014</td>
</tr>
<tr>
<td>20</td>
<td>20</td>
<td>0.016</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>0.018</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>0.020</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>0.022</td>
</tr>
</tbody>
</table>

# Hydrometer Analysis

- **PERCENT COARSER BY WEIGHT**
- **PERCENT FINER BY WEIGHT**
- **COBBLEREM %**: Percentage of cobbles removed from specimen; based on pre-removal total dry mass
- **< 2 μm %**: Percentage of soil particles finer than 2 micrometers (0.002 mm); clay-size fraction
- **NAT WC %**: Natural water content
- **Cu**: Coefficient of uniformity
- **Cc**: Coefficient of curvature
- **ASTM DES**: ASTM International test standard designation

---

**Univereity of Alaska Fairbanks**

Heat and Power Plant Replacement
Fairbanks, Alaska

**Grain Size Distribution**

**Boring 14-12**

2014 31-1-02399-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Design Alaska, Inc.

FIG. B-12

Sheet 1 of 1
**SIEVE ANALYSIS**

<table>
<thead>
<tr>
<th>GRAIN SIZE IN MILLIMETERS</th>
<th>NO. OF MESH OPENINGS PER INCH, U.S. STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>90</td>
<td>2</td>
</tr>
<tr>
<td>80</td>
<td>3</td>
</tr>
<tr>
<td>70</td>
<td>4</td>
</tr>
<tr>
<td>60</td>
<td>5</td>
</tr>
<tr>
<td>50</td>
<td>6</td>
</tr>
<tr>
<td>40</td>
<td>7</td>
</tr>
<tr>
<td>30</td>
<td>8</td>
</tr>
<tr>
<td>20</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>1</td>
<td>13</td>
</tr>
</tbody>
</table>

**HYDROMETER ANALYSIS**

<table>
<thead>
<tr>
<th>PERCENT COARSER BY WEIGHT</th>
<th>PERCENT FINER BY WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>90</td>
<td>1</td>
</tr>
<tr>
<td>80</td>
<td>2</td>
</tr>
<tr>
<td>70</td>
<td>3</td>
</tr>
<tr>
<td>60</td>
<td>4</td>
</tr>
<tr>
<td>50</td>
<td>5</td>
</tr>
<tr>
<td>40</td>
<td>6</td>
</tr>
<tr>
<td>30</td>
<td>7</td>
</tr>
<tr>
<td>20</td>
<td>8</td>
</tr>
<tr>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>1</td>
<td>12</td>
</tr>
</tbody>
</table>

**LEGEND**

- **USCS**: Unified Soil Classification System
- **COBBLE REM %**: Percentage of cobbles removed from specimen; based on pre-removal total dry mass
- **< 2 μm %**: Percentage of soil particles finer than 2 micrometers (0.002 mm); clay-size fraction
- **NAT WC %**: Natural water content
- **Cu**: Coefficient of uniformity
- **Cc**: Coefficient of curvature
- **ASTM DES**: ASTM International test standard designation

**SOIL CLASSIFICATION**

- **COARSE**: GRAVEL
- **MEDIUM**: SAND
- **FINE**: FINE
- **FINES**: SILT OR CLAY

**BORING AND SAMPLE NO.**

<table>
<thead>
<tr>
<th>DEPTH (feet)</th>
<th>USCS SYMBOL</th>
<th>SOIL CLASSIFICATION</th>
<th>GRAVEL %</th>
<th>SAND %</th>
<th>FINES %</th>
<th>COBBLE REM %</th>
<th>&lt; 2 μm %</th>
<th>NAT WC %</th>
<th>Cu</th>
<th>Cc</th>
<th>TEST BY</th>
<th>REVIEW BY</th>
<th>ASTM DES</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>SM</td>
<td>Silty sand with gravel</td>
<td>29</td>
<td>38</td>
<td>33.4</td>
<td>10.2</td>
<td></td>
<td></td>
<td>AMV</td>
<td>AMV</td>
<td></td>
<td></td>
<td>C136</td>
</tr>
</tbody>
</table>

**GRAIN SIZE DISTRIBUTION**

**BORING 14-14**

**Design Alaska, Inc.**

**University of Alaska Fairbanks**

Heat and Power Plant Replacement
Fairbanks, Alaska

2014

**SHANNON & WILSON, INC.**

Geotechnical and Environmental Consultants
APPENDIX C

SITE RESPONSE ANALYSIS
APPENDIX C

SITE RESPONSE ANALYSIS

TABLE OF CONTENTS

C.1 DESIGN GROUND MOTION LEVELS ................................................................. C-1
C.2 SITE RESPONSE ANALYSIS ........................................................................ C-1
   C.2.1 Uniform Hazard Ground Motion ........................................................ C-1
   C.2.2 Site Response Input Time Histories ..................................................... C-1
   C.2.3 Equivalent Linear Analysis ................................................................. C-2
      C.2.3.1 Shear Wave Velocity Profile ................................................... C-3
      C.2.3.2 Dynamic Soil Properties ......................................................... C-3
      C.2.3.3 Site Response Analysis Results ............................................... C-3
   C.2.4 Recommended Design Spectra ............................................................... C-4
C.3 REFERENCES .................................................................................................. C-4

TABLES

   C-1 Uniform Hazard Spectrum
   C-2 Selected Reference Time Histories
   C-3 Recommended Site Specific Design Spectrum

FIGURES

   C-1 Uniform Hazard Spectrum
   C-2 Reference Time History El Centro Array #1 140°
   C-3 Reference Time History El Centro Array #1 230°
   C-4 Reference Time History Freemont Emerson Ct. 180°
   C-5 Reference Time History HWA035 E
   C-6 Reference Time History HWA035 N
   C-7 Reference Time History Sitka Observatory 90°
   C-8 Reference Time History Wildlife Liquefaction Array 90°
   C-9 Matched Time History El Centro Array #1 140°
   C-10 Matched Time History El Centro Array #1 230°
   C-11 Matched Time History Freemont Emerson Ct. 180°
   C-12 Matched Time History HWA035 E
TABLE OF CONTENTS (cont.)

FIGURES (cont.)

C-13  Matched Time History HWA035 N
C-14  Matched Time History Sitka Observatory 90°
C-15  Matched Time History Wildlife Liquefaction Array 90°
C-16  Shear Wave Velocity
C-17  Modulus Degradation and Damping Curves
C-18  Lower Bound Ground Surface Acceleration Response Spectra
C-19  Best Estimate Ground Surface Acceleration Response Spectra
C-20  Upper Bound Ground Surface Acceleration Response Spectra
C-21  Site-Specific Response Spectrum
C-22  Recommended Design Spectra
APPENDIX C
SITE RESPONSE ANALYSIS

C.1 DESIGN GROUND MOTION LEVELS

We understand that the seismic design for the project will be in accordance with the International Building Code (IBC) (International Code Council, 2009). The IBC (2009) references the American Society of Civil Engineers (ASCE) Standard 7-05 (ASCE, 2005). The design ground motion in the IBC is the maximum considered earthquake (MCE), which corresponds to a 2,475-year return period ground motion.

C.2 SITE RESPONSE ANALYSIS

We performed equivalent linear total stress site response analyses to determine the soil response during the design ground motion level. Sets of spectrally matched time histories were used as input into the soil response model to develop ground surface response spectra for the design ground motion level in the project area. The site response analysis assumes ground improvement is performed as discussed in the main text of this report.

C.2.1 Uniform Hazard Ground Motion

Input ground motions required for the site response analysis correspond to a uniform hazard spectrum (UHS) (target spectrum). The UHS was obtained considering the 1999 and 2007 U.S. Geological Survey (USGS) probabilistic seismic hazard analyses (PSHA) performed for Alaska. The spectral acceleration values corresponding to the MCE design ground motion were obtained from the hazard curves provided on the USGS website using the latitude and longitude of the site. The spectral values were obtained for Site Class B condition. Shear wave velocities are based on downhole velocity measurements in borings 14-02, 14-03, and 14-06, as measured at the site during the subsurface exploration phase of the project. Figure C-1 presents the uniform hazard spectra design ground motion level for the project site. Data points for the UHS spectrum are provided in Table C-1.

C.2.2 Site Response Input Time Histories

We used deaggregation results from the USGS PSHA performed for this site to guide the selection of input time histories. The deaggregation results provide seismic source contribution, earthquake magnitude, and source-to-site distance that are the most significant contributors to ground motion hazard for a particular return period and spectral acceleration.
We selected a total of seven recorded strong ground motion acceleration time histories (i.e., seed motions or reference time histories) with characteristics similar (i.e., tectonic source, magnitude, distance, etc.) to those identified in the hazard deaggregation. The seven time histories were selected from different seismic source categories depending on their contribution to ground motion hazard. We reviewed available earthquake time history databases and selected reference time histories that have similar characteristics such as the seismogenic source and response spectrum shape. We reviewed the Pacific Earthquake Engineering Research Center database for crustal earthquake time histories. We also reviewed the Center for Engineering Strong Motion Data, USGS National Strong-Motion Project database, and the Center for Engineering Strong Motion Data. The reference time histories we selected for the MCE ground motion level are presented in Table C-2. This table provides the reference time history characteristics that are consistent, on average, with general characteristics of the seismic sources.

We spectrally matched the selected reference time histories to a corresponding UHS (target spectrum) for the design ground motion level. We performed spectral matching using the RSPM09 code (Al-Atik and Abrahamson, 2010) in the period range of 0.01 to 10 seconds. We filtered the spectrally matched time histories to remove the displacement offset imposed during the matching process. The selected reference time histories are plotted in Figures C-2 through C-8 and the spectrally matched time histories are plotted in Figures C-9 through C-15. The spectrally matched time histories represent the ground motions that correspond to site-specific MCE UHS.

### C.2.3 Equivalent Linear Analysis

We performed site response analyses using the program SHAKE2000 (Ordónez, 2007), which is a modified version of the original program SHAKE (Schnabel and others, 1972). The program uses an equivalent linear, total stress analysis procedure to compute the response of a one-dimensional, horizontally layered, visco-elastic system subjected to vertically propagating shear waves.

The equivalent linear method models the nonlinear variation of the soil shear moduli and damping as a function of shear strain using input shear modulus degradation and damping vs. strain curves. Given an initial estimate of the shear strains, the program determines values of dynamic moduli and damping ratios corresponding to the “effective” strain. An iterative procedure is used to arrive at moduli and damping values compatible with the calculated “effective” strains. The equivalent linear approach has been validated by many back-analyses of previous earthquakes.
C.2.3.1 Shear Wave Velocity Profile

Site-specific response spectra were estimated for subsurface conditions represented by the shear wave velocity determined from borings 14-02, 14-03, and 14-06 to provide a representation of the range of shear wave velocities that could be encountered at the site and considering the ground improvement that will be performed at the site. The soil model for the site response analyses was developed to reflect measured and estimated site-specific soil properties, and to consider variations and uncertainties in the thicknesses, shear wave velocities, and dynamic soil properties of the various soil units. Figure C-16 presents the three measured shear wave velocity (Vs) profiles, the generalized shear wave velocity profiles used for the soil model, and soil properties used in the site response analyses.

To provide a representation of the potential variability in subsurface conditions, the measured (or best estimate [BE]) shear wave velocity profile was varied by 30 percent (in log space). The above estimate of variability is based on our experience and typical variability. These varied shear wave velocity profiles were termed the lower-bound (LB) (-30 percent) and upper-bound (UB) (+30 percent) estimates of Vs.

C.2.3.2 Dynamic Soil Properties

Input properties for equivalent linear analysis include the shear wave velocity and soil unit weight (alternatively input as the maximum shear modulus) along with shear modulus degradation and damping vs. strain curves. The published curves used in our analyses included those by EPRI (1993) for sand and rock. These published curves are presented in Figure C-17.

C.2.3.3 Site Response Analysis Results

The program SHAKE2000 (Ordonez, 2007) was used to perform an equivalent-linear total stress analysis. Figures C-18 through C-20 show the ground motion response spectra at the ground surface for the LB, BE, and UB shear wave velocity profiles for the design ground motion level. The LB, BE, and UB acceleration response spectra are compared in Figure C-21, and site-specific spectra was obtained by weighted average (in log scale) of LB, BE, and UB spectra using 0.3, 0.4, and 0.3 weights, respectively. The higher weight of 0.4 was assigned to the BE spectrum recognizing that it corresponds to the “best estimate” shear wave velocity profile.
C.2.4 Recommended Design Spectra

We developed the ground surface acceleration design spectra from the site-specific ground response spectra for MCE ground motion level. As shown in Figure C-22, the recommended ground surface design spectra was determined as the smaller of the deterministic and the site specific spectrum based on ASCE 7-05. Also, ASCE 7-05 limits the site-specific spectrum to a 20 percent reduction of the IBC code-based spectrum. The recommended design spectrum is shown in Figure C-22 and the corresponding spectral values are in Table C-3.

C.3 REFERENCES


Schnabel, P.B.; Lysmer, John; and Seed, H.B., 1972, SHAKE, a computer program for earthquake analysis of horizontally layer sites: Berkeley, Calif., University of California, Report no. EERC 72-12, 46 p.
### TABLE C-1
UNIFORM HAZARD SPECTRUM

<table>
<thead>
<tr>
<th>Period (second)</th>
<th>Spectral Acceleration (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01</td>
<td>0.427</td>
</tr>
<tr>
<td>0.02</td>
<td>0.427</td>
</tr>
<tr>
<td>0.06</td>
<td>0.750</td>
</tr>
<tr>
<td>0.10</td>
<td>0.940</td>
</tr>
<tr>
<td>0.20</td>
<td>1.105</td>
</tr>
<tr>
<td>0.30</td>
<td>0.959</td>
</tr>
<tr>
<td>0.50</td>
<td>0.590</td>
</tr>
<tr>
<td>1.0</td>
<td>0.304</td>
</tr>
<tr>
<td>2.0</td>
<td>0.152</td>
</tr>
<tr>
<td>3.0</td>
<td>0.101</td>
</tr>
<tr>
<td>6.0</td>
<td>0.051</td>
</tr>
<tr>
<td>8.0</td>
<td>0.038</td>
</tr>
<tr>
<td>10.0</td>
<td>0.030</td>
</tr>
</tbody>
</table>
# TABLE C-2 REFERENCE TIME HISTORIES

<table>
<thead>
<tr>
<th>Mechanism</th>
<th>Strike-slip</th>
<th>Reverse</th>
<th>Reverse</th>
<th>Strike-slip</th>
<th>Strike-slip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Event</td>
<td>Imperial Valley</td>
<td>Loma Prieta</td>
<td>Chi-Chi</td>
<td>Sitka, Alaska</td>
<td>Superstition Hills</td>
</tr>
<tr>
<td>Earthquake Date</td>
<td>October 15, 1979</td>
<td>October 18, 1989</td>
<td>September 20, 1999</td>
<td>July 30, 1972</td>
<td>November 24, 1987</td>
</tr>
<tr>
<td>Station Name</td>
<td>El Centro Array #1</td>
<td>Fremont Emerson Court</td>
<td>HWA035</td>
<td>Sitka Observatory</td>
<td>Wildlife Liquefaction Array</td>
</tr>
<tr>
<td>Magnitude</td>
<td>6.5</td>
<td>6.9</td>
<td>7.7</td>
<td>7.7</td>
<td>6.2</td>
</tr>
<tr>
<td>Location</td>
<td>Mexico-California Border</td>
<td>Central California Coast</td>
<td>Central Taiwan</td>
<td>Southern Alaskan Coast</td>
<td>Southern California</td>
</tr>
<tr>
<td>Site Condition, Vs30 (m/sec)</td>
<td>237</td>
<td>285</td>
<td>474</td>
<td>660</td>
<td>208</td>
</tr>
<tr>
<td>Period (second)</td>
<td>Spectral Acceleration (g)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>--------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.00</td>
<td>0.351</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.01</td>
<td>0.353</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.02</td>
<td>0.361</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.03</td>
<td>0.364</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.05</td>
<td>0.450</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.08</td>
<td>0.557</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.08</td>
<td>0.589</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.15</td>
<td>0.820</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2</td>
<td>0.820</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.3</td>
<td>0.820</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.4</td>
<td>0.820</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>0.640</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.6</td>
<td>0.506</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.7</td>
<td>0.415</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.8</td>
<td>0.350</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.9</td>
<td>0.300</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>0.262</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td>0.187</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>0.162</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.7</td>
<td>0.143</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td>0.122</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2</td>
<td>0.111</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>0.097</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.7</td>
<td>0.090</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td>0.081</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5</td>
<td>0.069</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.061</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.049</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0.041</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>0.030</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>0.024</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. Uniform hazard spectrum are based on USGS PSHA 1999 and 2007 corresponding to Site Class B.

2. $g =$ acceleration due to gravity  
   USGS = U.S. geological survey  
   PSHA = probability seismic hazard analysis

NOTES

UNIFORM HAZARD SPECTRUM

University of Alaska Fairbanks  
Heat and Power Plant Replacement  
Fairbanks, Alaska

September 2014  
31-1-02399-001

SHANNON & WILSON, INC.  
Geotechnical and Environmental Consultants  
FIG. C-1
1. File: elcentro140-REF.avd
2. Reference time history is from an M6.5 Earthquake.
1. File: elcentro230−REF.avd
2. Reference time history is from an M6.5 Earthquake.
1. File: emerson180−REF.avd
2. Reference time history is from an M6.9 Earthquake.
1. File: hwa035E−REF.avd
2. Reference time history is from an M7.6 Earthquake.

(a) Acceleration vs. Time

(b) Velocity vs. Time

(c) Displacement vs. Time

(d) Spectral Acceleration vs. Period

(e) Spectral Velocity vs. Period

(f) Spectral Displacement vs. Period

(g) Normalized Arias Intensity vs. Time
1. File: hwa035N−REF.avd
2. Reference time history is from an M7.6 Earthquake.
1. File: sitka090−REF.avd
2. Reference time history is from an M7.7 Earthquake.
REFERENCE MOTION
1987 SUPERSTITION HILLS
WILDLIFE LIQUEF. ARRAY – 90°

September 2014  31–1–02399–001

1. File: superstition090−REF.avd
2. Reference time history is from an M6.2 Earthquake.
1. File: elcentro140−MATCH.avd
2. Reference time history is from an M6.5 Earthquake.
1. File: elcentro230-MATCH.avd
2. Reference time history is from an M6.5 Earthquake.
1. File: emerson180-MATCH.avd
2. Reference time history is from an M6.9 Earthquake.
1. File: hwa035E-MATCH.avd
2. Reference time history is from an M7.6 Earthquake.
1. File: hwa035N−MATCH.avd
2. Reference time history is from an M7.6 Earthquake.

**(a) Acceleration vs. Time**

![Acceleration vs. Time](image)

- PGA = 0.43 g

**(b) Velocity vs. Time**

![Velocity vs. Time](image)

- PGV = 0.97 ft/s

- Ending Vel = 0.00 ft/s

**(c) Displacement vs. Time**

![Displacement vs. Time](image)

- PGD = 0.76 ft

- Ending Displ = 0.00 ft

**d) Spectral Acceleration vs. Period**

![Spectral Acceleration vs. Period](image)

**e) Spectral Velocity vs. Period**

![Spectral Velocity vs. Period](image)

- PGA = 0.43 g

- PGV = 0.97 ft/s

**f) Spectral Displacement vs. Period**

![Spectral Displacement vs. Period](image)

**g) Normalized Arias Intensity vs. Time**

![Normalized Arias Intensity vs. Time](image)

- Arias Intensity = 9.15 ft/s
1. File: sitka090-MATCH.avd
2. Reference time history is from an M7.7 Earthquake.

(a) Acceleration vs. Time
(b) Velocity vs. Time
(c) Displacement vs. Time
(d) Spectral Acceleration vs. Period
(e) Spectral Velocity vs. Period
(f) Spectral Displacement vs. Period
(g) Normalized Arias Intensity vs. Time

PGA = -0.42 g
PGV = 1.50 ft/s
PGD = -0.77 ft
PGD = 0.77 ft
Arias Intensity = 8.04 ft/s
1. File: superstition090-MATCH.avd
2. Reference time history is from an M6.2 Earthquake.
1. Vs = shear wave velocity

**NOTES**

**SHEAR WAVE VELOCITY**

September 2014

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

University of Alaska Fairbanks
Heat and Power Plant Replacement
Fairbanks, Alaska
MODULUS DEGRADATION

- EPRI (1993) Soil 0-6 meters (0-20ft)
- EPRI (1993) Soil 15-36 meters (51-120ft)
- EPRI (1993) Rock 77-152 meters (251-500ft)

DAMPING

- EPRI (1993) Soil 0-6 meters (0-20ft)
- EPRI (1993) Soil 15-36 meters (51-120ft)
- EPRI (1993) Rock 77-152 meters (251-500ft)

University of Alaska Fairbanks
Heat and Power Plant Replacement
Fairbanks, Alaska

MODULUS DEGRADATION
AND DAMPING CURVES

September 2014
31-1-02399-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants
FIG. C-17
NOTES
1. UHS = uniform hazard spectrum
   g = acceleration due to gravity

University of Alaska Fairbanks
Heat and Power Plant Replacement
Fairbanks, Alaska

LOWER BOUND
GROUND SURFACE ACCELERATION RESPONSE SPECTRA
September 2014

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-18
1. UHS = uniform hazard spectrum
   g = acceleration due to gravity
NOTES
1. UHS = uniform hazard spectrum
   g = acceleration due to gravity

UPPER BOUND
GROUND SURFACE ACCELERATION
RESPONSE SPECTRA
September 2014 31-1-02399-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants
FIG. C-20
NOTES
1. See text for explanation of lower bound, best estimate, and upper bound profiles.
2. g = acceleration due to gravity
NOTES
1. See text for explanation of maximum considered earthquake (MCE) and the procedure used to calculate design spectrum.
2. \( g \) = acceleration due to gravity

RECOMMENDED DESIGN SPECTRA

University of Alaska Fairbanks
Heat and Power Plant Replacement
Fairbanks, Alaska

September 2014

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. C-22
APPENDIX D

LIQUEFACTION ANALYSES RESULTS
APPENDIX D

LIQUEFACTION ANALYSES RESULTS

TABLE OF CONTENTS

FIGURES

D-1 Results of Liquefaction Analyses Boring 14-01
D-2 Results of Liquefaction Analyses Boring 14-02
D-3 Results of Liquefaction Analyses Boring 14-03
D-4 Results of Liquefaction Analyses Boring 14-04
D-5 Results of Liquefaction Analyses Boring 14-05
D-6 Results of Liquefaction Analyses Boring 14-06
D-7 Results of Liquefaction Analyses Boring 14-07
D-8 Results of Liquefaction Analyses Boring 14-08
The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.

NOTES

1. See main text for references.

2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
1. See main text for references.

2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.

1. See main text for references.

2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
1. See main text for references.

2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.

1. See main text for references.
2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
1. See main text for references.

2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
1. See main text for references.

2. The liquefaction resistance of a soil is based on its density and fines content. We used the results of the standard penetration testing to estimate the density, and the results of selected laboratory tests to estimate the fines content.
APPENDIX E

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT
IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT’S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include: the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used: (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors which were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.
A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland