Design Criteria

AECOM

Project Name:	**Replace Arc Jet Complex SVS Boiler**	
Project No.:	**60212932**	**Issue Date: 1/25/12**
Discipline Element:	**Civil**	

Eric Frampton / 12-12-12 Preparer / Date	**Robert Croeni / 12-12-12** Reviewer / Date

Objective

Provide civil design for the Replace Arc Jet Complex Steam Vacuum System (SVS) Boiler project, including existing utility demolition and rerouting, installation of new utilities, site perimeter fence layout and foundations, site restoration and traffic control.

Prerequisites (Input)

- Identify Required Formats: Unified Facilities Guide Specifications (UFGS) specifications, AutoCAD 2011 Civil 3D
- Design Results From Other Disciplines:
  a. Electrical layout for site electrical distribution;
  b. Mechanical yard area piping and equipment layout
  c. Structural footing layout
- Pertinent Test Data or Analyses Required: Underground utility per formed by GeoTECH Utility Locating LLC.
- Required Test Data For Field Verification.: Chemical analysis's of existing site soils found in Geotechnical Investigation Report provided Furgo West, Inc. (Project No. 04.71110005, May 2011)

Design Elements

- Design Criteria: Established in the PER Construction of Facility (CoF) - FY2013 Program Replace Arc Jet Complex Steam Vacuum System Boiler Preliminary Engineering Report (PER), Document No. A231A-1101-XR2, August 11, 2011
- Client specifications: Established in PER (Document No. A334A-1101-XR2) and Replace Arc Jet Complex Steam Vacuum System Boiler Functional Requirements Document (FRD), and TSF Branch Requirements Document No. A334A-1100-XR1, Rev. B, May 11, 2011. Codes, Regulations and Standards:
  a. ASCE 7-05 Minimum Design Loads of Buildings and Other Structures
  b. Bay Area Air Quality Management District (BAAQMD) Regulations
  c. California Building Code (CBC), 2010
  d. Nondestructive Testing Recommended Practice No. SNT-TC-1A
  e. NASA Ames Environmental Procedural Requirements; Chapter 12 Storm Water Management
  f. Santa Clara County Department of Environmental Health: "HazMat Program Ordinance Code, Division B11, Envornmental Health, Chapter XIII
- Standard Corporate AECOM Protocols:
  a. AECOM CAD Standards
  b. Q4NA-331-GL1, Guidelines for the Preparation of Calculations
  c. Q4NA-331-GL2, Guidelines for the Preparation of Drawings

d. Q4NA-331-GL3, Guidelines for the Preparation of Specifications
e. Q3NA-351-FM1, Calculation Review Checklist
f. Q3NA-351-FM2, Drawing Review Checklist
g. Q3NA-351-FM3, Specification Review Checklist

- Design Loads:
  a. H20 traffic loading for pavement design.
- Design Approach:
  a. Standard civil engineering practice for site grading:.5% slope for curbs and gutters; Portland Cement concrete slabs min slope: .5% to 1% sheet flow; asphaltic concrete minimum slope standards 1.5% to 2% sheet flow; ramps 8.33% per Architectural Barriers Act and CBC 2010. In Areas North and East of the Mat slab the existing slopes are flatter than .5% we are recommending valley gutter slope of .2% min for concrete and 1% slopes for asphalt swales.
  b. Design approach for utilities, shall be coordinated with Mechanical and Electrical disciplines for the removal of abandoned utilities as well as temporary relocation of existing utilities for electrical and mechanical.
  c. The exterior fence is designed to be 7'-0" high. It is to have three 10'-0"+/- sliding gate access points, (3) 12'-0" sliding gates and one 4'-0" man gate with card reader. The fence posts are to be placed in a concrete foundation separated from the Mat slab by 2'-3" from from centerline of post to the inside edge of the foundation. A portion of the fence is located within the south east quadrant of the mat slab therefore, some of the fence posts will have base plates to be secured on the concrete mat slab.
  d. Traffic control shall be based on 2010 California Manual on Uniform Traffic Control Devices. Traffic shall be controlled by signage and cones where the California Manual on Uniform Traffic Control Devices allows for a lane closure on urban roads where speed limit is less than 45 MPH and is not heavily traveled. Vehicles in the east bound lane along Hunsaker Road will yield to oncoming traffic prior to entering the west bound lane.
  e. Site Restoration, shall be addressed in the Storm Water Pollution and Best Management Practices Plan on nearby utilities and open / exposed land as required by National Pollutant Discharge Elimination System.
  f. The south and south east exterior of building N231 shall include new ADA accessible sidewalk with two ADA accessible parking stalls located outside in front of the south exit/entry to building N231 per the Architectural Barriers Act and CBC 2010. The remainder of the parking stalls are for motorcycles and regular vehicular parking.
  g. Three way valve is to provide an immediate backup of domestic water supply in the event the reverse osmosis water supply loses pressure.
- Assumptions:
  a. No retention requirement
  b. National Pollutant Discharge Elimination System requirements to be addressed as shown on sheet C107 Storm Water Pollution Prevention and Best Management Practices Plan.
  c. Storm Drainage assumptions are based on the sheet flow on the Eastern side of the Canopy that tends to drain toward Hunsacker between buildings N238A and

Project Name:	Replace Arc Jet Complex SVS Boiler	
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Discipline Element:	Civil	

N238 Northward. Three quarters of the Storm drainage collected form canopy will be collected by roof gutters/drains and ultimately sheet flow north east of the proposed pad. The remaining one quarter will be collected in the same manner and ultimately sheet flow to the south west side of the proposed pad to an existing drainage inlet.

d. Site grading assumptions existing grades tend to slope North East away from building N231 with some areas that may require re-grading to allow for positive drainage.

e. Elevation of existing utilities crossing proposed utilites to be determined by GeoTech Utility Locating LLC.

Interdisciplinary Coordination

- Mechanical – Main Natural Gas Line coordination, shown on Site Utility Plan detailing point of connection near Building N234A and point of termination at the Mat Slab where Mechanical Engineering Plans extend the gas line per Mechanical Plans.
- Electrical – Electrical main power feed for Building N231 to be rerouted, pad locations, and main transformer for the Boiler plant to be shown
- Structural – Mat slab location, dimensions, slopes, elevations, fence access slab with details, differential settlement between mat slab and concrete footing and expansion joints for the abutting concrete fence and access slabs.
- Architectural – Elevations for the SVS Mat Slab and down spout locations for Canopy drainage. Building N231 roof drains and rerouting drains to the West and to the East.

Design Criteria

AECOM

Project Name:	**Replace Arc Jet Complex SVS Boiler**	
Project No.:	**60212932**	**Issue Date: Aug. 24, 2012**
Discipline Element:	**Architectural**	
Tom Wong / March 2012 Preparer / Date	**David Crawford / 8/22/12** Reviewer / Date	

Objective

- Provide architectural design for the Replace Arc Jet Complex Steam Vacuum System (SVS) Boiler project, including an overhead open air canopy with a metal roof cover, a new control room (Room 110) for the plant located within an existing room located at the southeast corner of building N231 and providing ADA compliant toilet (Room 113) and shower (Room 114) facilities.

Prerequisites (Input)

- Identify Required Formats: UFGS specifications, Revit Architecture 2011
- Design Results From Other Disciplines:
    a. Overall plant general arrangement drawing(s) for establishing canopies and elevated equipment platforms (with vertical access), to the extent and elevation for the boiler and deaerator areas.
- Pertinent Test Data or Analyses Required: None
- Required Test Data: None

Design Elements

- Design Criteria: Established in the PER Construction of Facility (CoF) - FY2013 Program Replace Arc Jet Complex Steam Vacuum System Boiler Preliminary Engineering Report (PER), Document No. A334A-1101-XR2, June 7, 2012.
- Client specifications: Established in PER (Document No. A334A-1101-XR2); Replace Arc Jet Complex Steam Vacuum System Boiler Functional Requirements Document (FRD), Document No. A334A-1101-XR2, June 7, 2012; and TSF Branch Requirements Document No. A334A-1100-XR1, Rev. B, June 30, 2011.
- Codes, regulations and standards: California Building Code (CBC) 2010 includes, but is not limited to the following requirements:
    a. Building N231
        - The existing building is F-2 Occupancy, Low Hazard.
        - Building Construction is Type III-B (Building contains no automatic sprinkler system.)
        - CBC 1115B, for complaint restroom and shower.
        - CBC 1127B, for accessible route of travel.
        - Accessible parking and route of travel to be addressed by Civil
    b. Boiler and Deaerator Yard Canopy
        - The new open air exterior canopy will be considered a F-2 Occupancy and of Type III-B Construction, thus matching and becoming an extension of Building N231. Per CBC 503.1.1 Special Industrial occupancies; buildings and structures housing special industrial processes, are exempt from the building height and area limits of Table 503.
        - CBC 502 and 505.5, definition of Equipment Platform
        - CBC 1009, Exception 2 for (open riser) stair design

- o CBC 1013 for guardrail design
- o Outdoor area: 13,000 SF gross

  Per Table 1004.1.1, Occupant Load Calculation, Mechanical Equipment Room of 300 SF per occupant: 13,000 (gross) SF / 300 Occupant = 44 Occupants in enclosed yard (per 11/9/2011 mtg with NASA Fire Marshal, Occupant Load calculation in outdoor yard may be based on net area and not gross)
- o Per Table 1015.1, single exit permitted when occupant load of <49
- o Per Table 1016.1, maximum travel distance is 300'

c. Bay Area Air Quality Management District (BAAQMD)

- o Regulation 8 Organic Compounds, Rule 3 Architectural Coatings (8-3-301, Table 2)

- Standard Corporate Protocols:
  a. AECOM CAD Standards
  b. Q4NA-331-GL1, Guidelines for the Preparation of Calculations
  c. Q4NA-331-GL2, Guidelines for the Preparation of Drawings
  d. Q4NA-331-GL3, Guidelines for the Preparation of Specifications
  e. Q3NA-351-FM1, Calculation Review Checklist
  f. Q3NA-351-FM2, Drawing Review Checklist
  g. Q3NA-351-FM3, Specification Review Checklist
- Design Approach:
  a. Building N231
    - o The proposed Control Room within the building:
      - To receive new 2'x4' lay-in ceiling (to match existing height of 8'-6")
      - To receive new VCT flooring,
      - To receive freshly painted walls with patching and repairs as needed
      - The existing floor trenches and covers in the room will remain as is.
      - Doors to the Control Room will be replaced for new security control devices. All entries into the Control Room will be controlled by acard reader. (The existing low-voltage power supplies and control panel for security hardware devices in Building N231, may not be adequate. In such cases, new items will be provided as appropriate.)
      - No freestanding room furnishings (i.e., desks, tables, chair, caseworks, etc.), will be provided by architectural.
      - Existing window blinds will be replaced.
      - New built-up roofing with a cap sheet and sheet metal roofing work associated with replacing control room roof top mechanical unit and ductwork.
      - Provide new Unisex ADA compliant restroomwith a separate Unisex accessible shower unit (per client request).
    - o Provide a new 7'-0" tall floor mounted steel enclosure within the high-bay space. Minimum size of 850 SF. Primary entry will be by a single leaf 3'-0" gate with keypad. Equipment access will be thru a 6'-0" gate. A top lid will not be required.
    - o New ADA compliant Unisex Toilet and Shower Rooms:
      - The existing Men's Room (Room 113), will be demolished and divided into separate Single User Toilet and Single User Shower

Room. Both rooms will be accessible.

- The new shower will require cutting of the existing concrete floor for proper slope/drainage, and installation of a new tile floor.
- For purposes of building code compliance, the existing Women's Room #106), will be re-designated as a Unisex toilet, and will remain in-accessible.
- Appropriate accessible signage will be provided as per CBC 1117B.5.

b. Boiler and Deaerator equipment platform

- Walking platform surfaces to be open bar grating, galvanized metal.
- Stair design to be open riser and galvanized. (Note: Open riser stairs are permitted per CBC 1009.4.5, Exception 2 for F Occupancies.)
- Ladders and safety cages (if required), will be galvanized only. (At this time, all such ladders and safety cages will be provided by the Mechanical Boiler and Deaerator vendor.)
- Metal guard rails,galvanized.
- Jib crane for lifting of deaerator components. Capacity will be one ton and location will be shown on structural drawings.

c. Boiler and Deaerator Yard Canopy

- Provide a new canopy for weather protection of the equipment and personal. To mitigate some wind driven rain, side skirts will also be provided.
- Structure of canopy (columns and beams), to be factory finished with a pigmented polyurethane coating over an epoxy system.
- Fence enclosure and gates around yard area by Civil.
- Entry/exit to building N231 from Yard area will be through an existing door on the north side of N231. This door will have a card reader on both the building and yard side of the door. As a result, ***this door will not be considered as a means of egress for either building N231, or the Yard enclosure***. (It is NASA's intent that all entry doors into N231 be by card reader. This has resulted in the design condition with two security zones with a common boundary and access point, and the reason why a card reader is being located on both sides of this door.)
- Direct entry into the Yard enclosure will be thru an exterior chain link gate equipped with a card reader.

Interdisciplinary Coordination

- Civil – For accessible parking, path of travel and canopy rainwater drainage locations.
- Structural – Canopy design, equipment platform support, jib crane for equipment lift.
- Mech/Plumbing – Control room, boiler and deaerator on equipment pads, canopy and equipment platform layout, jib crane for equipment lift.

Electrical – Control room layout and security door devices

Design Criteria

AECOM

Project Name:	**Replace Arc Jet Complex SVS Boiler**	
Project No.:	**60212932**	**Issue Date: Aug. 24, 2012**
Discipline Element:	**Structural**	

Nutan Shah / July 12, 2012 Preparer / Date	**Azita Firouzi / August 24, 2012** Reviewer / Date

Objective

Provide structural design for the Replace Arc Jet Complex Steam Vacuum System (SVS) Boiler project, including the boiler mat slab,pipe support foundations, platform and walkway steel structure, and steel canopy structure.

Prerequisites (Input)

- Identify Required Formats: UFGS specifications, Revit Structure 2011
- Design Results From Other Disciplines including but not limited to:
  a. Mechanical and Electrical equipment dead weights
  b. Piping analyses support loads for sustained, expansion, and occasional loads.
- Pertinent Test Data or Analyses Required: None.
- Required Test Data For Field Verification: None.
- Soil Report

Design Elements

- Design Criteria: Established in the PER Construction of Facility (CoF) - FY2013 Program Replace Arc Jet Complex Steam Vacuum System Boiler Preliminary Engineering Report (PER), Document No. A334A-1101-XR2, June 7, 2012.
- Client specifications: Established in PER (Document No. A334A-1101-XR2); Replace Arc Jet Complex Steam Vacuum System Boiler Functional Requirements Document (FRD), Document No. A334A-1101-XR2, June 7, 2012; and TSF Branch Requirements Document No. A334A-1100-XR1, Rev. B, June 30, 2011.
- Codes, Regulations and Standards:
  a. California Building Code, 2010 Edition
  b. ASCE 7-05, Minimum Design Loads for Buildings and Other Structures.
  c. AISC Manual of Steel Construction, 13th Edition.
  d. ACI 318-08, American Concrete Institute, Building Code requirements for Structural Concrete
- Standard Corporate Protocols:
  a. AECOM CAD Standards
  b. Q4NA-331-GL1, Guidelines for the Preparation of Calculations
  c. Q4NA-331-GL2, Guidelines for the Preparation of Drawings
  d. Q4NA-331-GL3, Guidelines for the Preparation of Specifications
  e. Q3NA-351-FM1, Calculation Review Checklist
  f. Q3NA-351-FM2, Drawing Review Checklist
  g. Q3NA-351-FM3, Specification Review Checklist
- Design Loads:

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Discipline Element:	**Structural**	

a. Dead Loads
   - Dead Loads are based on the manufactures published documents for operating weight of equipments

b. Live Loads
   - Roof live load = 20 psf (Reducible)
   - Walkway = 50 psf (Nonreducible)
   - Mat foundation = 250 psf, or Actual operating weight of equipment.

c. Seismic Loads
   - Occupancy Category III (Per Owner (Arc Jet Facility) request)
   - Seismic Design Category = D
   - Importance Factor = 1.25 (Except for components design under ASME code I=1.5)
   - Spectral response acceleration Ss = 1.5
   - Spectral response acceleration S1 = 0.6
   - Site Class “D”
   - Site Coefficient Fa = 1.0
   - Site Coefficient Fv = 1.5

d. Wind Loads
   - Basic Wind Speed = 85 mph
   - Exposure = “B”
   - Occupancy Category III (Per Owner (Arc Jet Facility) request)
   - Importance Factor I = 1.15

e. Material Properties
   - Concrete Compressive Strength, Fc = 4000 psi
   - Reinforcing Steel, ASTM A615, Grade 60 ksi
   - Steel Wide Flange shapes, ASTM A992, Fy = 50 ksi
   - Steel Hollow Structural Section, ASTM A500, Grade B, Fy = 46 ksi
   - Steel Pipe, ASTM A53, Grade B, Fy = 35 ksi
   - Other steel shapes and plates, ASTM A36, Fy = 36 ksi
   - Anchor Bolts, ASTM F1554, Grade 36 ksi
   - Welding Electrodes for structural steel, E70XX
   - High Strength Bolts, ASTM A325N, unless otherwise noted.

f. Load Combination
   Strengtrh Design ASCE 7-05 Section 2.3.2
   - 1.4 D
   - 1.2 D + 1.6 L +0.5Lr
   - 1.2 D + 1.6 Lr +0.8W
   - 1.2 D + 1.6 W +0.5Lr
   - 1.4 D + (Rohe) E
   - 0.9 D + 1.6 W
   - 0.7 D + (Rohe) E
   - 1.4 D + (Omega) E
   - 0.7 D + (Omega) E

Allowable Strength Design ASCE 7-05 Section 2.4.1

- o D + Lr
- o D + W
- o 1.14 D + 0.7(Rohe) E
- o D + 0.75 W +0.75 Lr
- o 1.1 D + 0.75(0.7)(Rohe) E+0.75 Lr
- o 0.6 D + W
- o 0.46 D + 0.7(Rohe) E
- o 1.14 D + 0.7(Omega) E
- o 1.105 D + 0.525 (Omega) E +0.75 Lr
- o 0.46 D + 0.7(Omega) E

- Analysis Methods and Design Approach:
  a. Hand calculation, RISA-3D, ENERCALC and MathCAD software will be used for analysis and design approaches
  b. Foundation

     The foundation design is based on geotechnical report recommendations by Fugro West, Inc. (Project No 04.71110005, dated May 2011). Based on recommendations, the Boiler Plant is supported on a structural mat foundation.

     The boiler tanks foundation is to be placed in the area of the existing Vacuum Spheres #5 and #6. The existing Vacuum Spheres foundation system consists of 12 pedestal footings approximately 6'-6" below ground surface. Each footing is 9'-6" square, and 2'-4" thick. Each pedestal has 3'-6" square piers that extends out to the ground surface. The individual foundations are tied together with a 24" deep by 12" wide grade beam.

     The new mat foundation is supported on the existing pedestal foundations, with 3'-6" square portion of concrete piers that extend to the ground shall be removed; however 9'-6" square portion of the existing foundation will remain in place.

     Net Allowable bearing pressure for dead + live = 1000 psf, and for dead + seismic = 3000 psf.
     Passive pressure (Equivallent Fluid Pressure) = 300 pcf (upper 1-foot of soil will be ignored, unless the soil is confined by a pavement or slab).
     Friction coefficient between soil and concrete = 0.30
     Resistance to lateral loads can be assumed through a combination of friction and passive pressure.
  c. Canopy Structural System

     The canopy structure is a detached building, rectangle in plan, approximately 86 feet wide by 143 feet long. It will be used for the protection from rain and sun for the 3-Boilers and its supporting equipment, and Deaerator tank with its supporting equipment. The roof framing system consists of a metal desk supported by steel wide flange beams and girders. Steel columns are spaced to accommodate the boilers, deaerator, platforms and piping.

     The metal roof decking acts as a diaphragm to distribute the lateral forces to vertical bracing system in both directions. All lateral loads are then transfer to foundation through vertical bracings.

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Discipline Element:	Structural	

The exterior of the canopy will have 10 feet deep skirt on all sides of the canopy. The skirt will be supported by horizontal girts and sag rods.

- Assumptions:
  a. Boiler foundation design will be based on the vendor drawings provided by the mechanical engineer; however the final design of foundation will be verified with the contractor's procured boilers.
  b. Pipe Support structures and footings are designed to R value specified on ASCE 7 chapter 15 Tables 15.4-1 & 15.4-2. All pipe support elements are designed for deflection with R=1.

Interdisciplinary Coordination

- Foundation and steel structure designs will be interfaced with the mechanical & architectural discipline. The size of the mat foundation and elevation of the pad will interface with Civil & Architectural discipline.

Design Criteria

Project Name:	**Replace Arc Jet Complex SVS Boiler**	
Project No.:	**60212932**	**Issue Date: Dec. 12, 2012**
Discipline Element:	**Mechanical**	

Michael Callahan / 12.12.12 Preparer / Date	**Paul Yallouris / 12.12.12** Reviewer / Date

Objective

- Provide mechanical design for the Replace Arc Jet Complex Steam Vacuum System (SVS) Boiler project, including piping, equipment and pipe support design.

Prerequisites (Input)

- Identify Required Formats: UFGS specifications, Revit 2011
- Design Results From Other Disciplines:
  a. Architectural and Structural: Canopy structure and foundations
  b. Architect: Tenant improvement design of control room envelope
  c. Civil: Points of connection for utilities
  d. Electrical: Tenant improvement lighting design of control room, power for boiler plant
- Pertinent Test Data or Analyses Required:
  a. Supply water temperature for heating water system
  b. Water pressure available for heating water piping
  c. Failure Mode and Effects Analysis (FMEA)
  d. Preliminary Hazard Analysis
- Required Test Data: None
- Required Field Data:
  a. Existing equipment dimensions, weights, nozzle locations, specifications

Design Elements

- Design Criteria: Established in the PER Construction of Facility (CoF) - FY2013 Program Replace Arc Jet Complex Steam Vacuum System Boiler Preliminary Engineering Report (PER), Document No. A334A-1101-XR2, June 7, 2012.
- Client specifications: Established in PER (Document No. A334A-1101-XR2); Replace Arc Jet Complex Steam Vacuum System Boiler Functional Requirements Document (FRD), Document No. A334A-1101-XR2, June 7, 2012; and TSF Branch Requirements Document No. A334A-1100-XR1, Rev. B, June 30, 2011.

Project Name:	Replace Arc Jet Complex SVS Boiler	
Project No.:	60212932	Issue Date: Dec. 12, 2012
Discipline Element:	Mechanical	

- Codes and Regulations [PER]:
  a. California Code of Regulations (2010), CBC, CMC, CPC, CEC
  b. ASME BPVC (2010) Section I, Section IV, and Section VIII
  c. ASME B31.1 Power Piping (2010)
  d. ASME B31.3, Process Piping (2010)
  e. ASME B31.9, Building Services Piping (2011)
  f. BAAQMD, Regulation 9, Rule 7 (2011)
  g. Santa Clara County Hazardous Materials Storage Ordinance
- Standards:
  a. ASHRAE Handbooks (2009, 2010, 2011, 2012)
  b. ASHRAE Standard 15 (2010): Safety Code for Mechanical Refrigeration
  c. ASHRAE Standard 52.2 (2007): Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
  d. ASHRAE Standard 55 (2010): Thermal Environmental Conditions for Human Occupancy
  e. ASHRAE Standard 62.1 (2010): Ventilation for Acceptable Indoor Air Quality
  f. ASHRAE Standard 90.1 (2010): Energy Standard for Buildings
  g. ASHRAE Standard 100 (2006): Energy Conservation in Existing Buildings
  h. ASHRAE Standard 111 (2008): Practices for Measurement, Testing, Adjusting and Balancing of Building HVAC Systems
  i. ASHRAE Standard 113 (2009): Method of Testing for Room Air Diffusion
  j. ASHRAE Guideline #4 (2008): Preparation of Operating and Maintenance Documentation for Building Systems
  k. ASHRAE Guideline #12 (2000): Minimizing the Risk of Legionellosis
  l. American Society of Plumbing Engineers ASPE Data Books,
  m. SMACNA HVAC Duct Construction Standards: Metal and Flexible (2005)
  n. SMACNA HVAC Air Duct Leakage Test Manual (1985),
  o. SMACNA Seismic Restraint Manual Guidelines for Mechanical Systems (2008)
  p. NFPA 30 Flammable and Combustible Liquids Code (2012)
  q. NFPA 54 National Fuel Gas Code (2012)
- Standard Corporate Protocols:
  a. AECOM CAD Standards
  b. Q4NA-331-GL1, Guidelines for the Preparation of Calculations
  c. Q4NA-331-GL2, Guidelines for the Preparation of Drawings
  d. Q4NA-331-GL3, Guidelines for the Preparation of Specifications
  e. Q3NA-351-FM1, Calculation Review Checklist
  f. Q3NA-351-FM2, Drawing Review Checklist
  g. Q3NA-351-FM3, Specification Review Checklist

Mechanical General:

SVS steam loads and load profiles: Code TSF Requirements [PER]
HVAC loads: See *HVAC Load Design Criteria*

For critical vs. noncritical piping classification and required design approach, see drawing M603, Piping System Data Table.

Seismic Design requirements (mechanical, non-structural):

Spectral response acceleration (S_s): 1.5 [AF]
Spectral response acceleration (S_1): 0.6 [AF]
Site Class: D [AF]
Site coefficient (F_a): 1.0 [ASCE 7, Table 11.4-1]
Site coefficient (F_v): 1.5 [ASCE 7, Table 11.4-2]
Design spectral response acceleration (S_{DS}): 1.0 [ASCE 7, Eq.11.4-1 and 11.4-3]
Design spectral response acceleration (S_{D1}): 0.6 [ASCE 7, Eq.11.4-2 and 11.4-4]
Design Category: D [ASCE 7, Tables 11.6-1 and 11.6-2] [ASCE 7, 13.2.2]
Component importance factor (Ip): 1.5 [NASA Pressure Systems Manager]

Piping Component Response Modification Factors (Rp):

For non-critical piping (as per drawing M603), the maximum piping component response modification factor, R_p = 3.5, [D. .Fraser]. Also,

- The maximum component force equation of ASCE 7 equation 13.3.2 shall not apply
- The minimum component force of equation 13.3.3 shall be met.

For critical piping (as per M603), the component response modification factor Rp = 1.

Other amplification and response modification factors, non-critical piping [ASCE Table 13.6-1]:

- Noncritical Piping ASME B31 (welded or brazed): a_p=2.5, Rp = 3.5
- Noncritical Piping ASME B31 (threaded, bonded, compression, grooved): a_p=2.5, Rp = 3.5
- Noncritical Piping non-ASME B31 (welded or brazed): not permitted
- Noncritical Piping non-ASME B31 (threaded, bonded, compression, grooved): not permitted
- Piping low-deformability (cast iron, glass nonductile plastic): not permitted
- Ductwork (welded or brazed): a_p=2.5 R_p=9.0 [breeching]
- Ductwork (not welded or brazed): a_p=2.5 R_p=6.0
- Plumbing: a_p=1.0 R_p=2.5
- Heat exchangers, pumps: a_p=1.0 R_p=2.5
- Other boilers and pressure vessels: a_p=1.0 R_p=2.5
- HVAC rooftop unit: a_p=2.5 R_p=6.0
- Boiler stacks: a_p=2.5 R_p=3.0
- Other mechanical: a_p=1.0 R_p=1.5

Boilers and Pressure Vessels - Design and Analysis Requirements:

General:

Section I Boilers: Design per ASCE 7, Chapter 15 including explicit consideration of hydrodynamic (sloshing) effects as required in section 15.7, and dynamic coupling of vessels and their supporting structures as required by sections 15.3.2 and 15.7.11.4

Deaerator/feedwater Tanks: Design per ASCE 7, Chapter 15 including explicit consideration of hydrodynamic (sloshing) effects as required in section 15.7, and

dynamic coupling of vessels and their supporting structures as required by sections 15.3.2 and 15.7.11.4

Other Pressure Vessels and Tanks: Design per ASCE 7, Chapter 15. Use Chapter 13 only if it can be demonstrated that equipment is within that Chapter's scope.

Nozzle Loads:
Pressure vessel nozzles shall accommodate external loads on the nozzles from the piping as specified by the piping designer, and shall meet applicable load limits established by the vessel manufacturer. In the absence of manufacturer's nozzle load limits, the approach and stress limits of WRC 107 / 297 shall be used, or the nozzles shall be qualified using explicit finite element analysis with stress categorization per Section VIII, Div 2 and allowable stress per Section I or VIII, Div. 1. All applied nozzle loads from piping shall be developed with Rp = 1.

Vessels on Elevated Structures
The structural support system for vessels attached to elevated frame structures shall be designed such that the vessel's total actual displacement (i.e., not reduced by Rp) due to the design seismic loading is consistent with the displacement of the vessel and its nozzles used in the piping analysis.

Piping Design and Analysis Requirements:

For critical piping, all B31 and Section I piping design shall be accomplished using computer dynamic linear modal response spectrum analyses using the latest version of the Caesar II software (Intergraph Corp.). All computer model input and database files shall be provided to NASA for review and approval prior to fabrication, and as-built reconciliation analyses shall be performed by the contractor and provided to NASA for review and approval prior to job completion.

Computer models for critical piping shall include actual pipe support stiffnesses between the pipe and the attached structural load path to ground. The reference plant design explicitly modeled the complete structural load paths to ground for pipe supports attached to virtually all major structures, equipment and vessels. Explicit coupled equipment models were also used to determine dynamic characteristics and nozzle displacements, and such an approach is recommended to minimize conservatism in the design. If structure and equipment models are not explicitly included in the critical piping computer models and analyses, then:

1. The support stiffness between the pipe centerline and building structure must still be included in the analytical model.
2. Actual displacements at equipment nozzles shall be determined and applied as anchor motions.
3. The ASCE 7 equation 13.3-1 amplification factor (1+2z/h) shall be applied to the input spectrum at every support point not anchored to ground in the model.
4. Actual seismic anchor movement (SAM) displacements (not reduced by R or Rp) must be applied at the pipe supports between the various elevations of the supporting structure, between independently supported structures such as between the Deaeartor tank frame and the pipe support catwalk and the individual boiler supporting structures, and at equipment connections (such as at boiler and

pressure vessel nozzles, heat exchanger nozzles, tanks and pumps). The stresses and loads resulting from such applied SAMs shall be evaluated in accordance with the rules of the applicable design Code.

The exclusion of explicit structure models (while meeting the above provisions for critical piping) is likely to be more conservative than the approach used in the reference plant design, and may result in substantially greater loads, displacements and restraint requirements than the reference plant design. It is the contractor's responsibility to assess the tradeoffs in choosing which approach to follow, and to meet all of the requirements and good engineering practice of the selected method.

Critical piping components having extended operators that significantly shift the center of gravity of the component away from the piping centerline shall be modeled explicitly in the dynamic analysis. Such components on noncritical piping shall be individually supported using the force equations of ASCE 7 chapter 13 for the total weight of the component and operator.

As-built reconciliation analyses of critical piping shall be performed for all relevant construction deviations from the approved design (e.g., changes in piping and equipment layout, support locations, pipe support stiffness, weight changes, etc.). Relevant changes in pipe support loads, pipe stress, nozzle loads, system displacements, etc. resulting from such construction changes shall either be documented as acceptable per the applicable design Code and vendor limits, or modifications shall be performed by the contractor in order to achieve Code and vendor limit compliance.

<u>Nozzle, component, and vendor load and displacement qualification requirements:</u>
All piping, equipment and components having load or deflection limits, including published vendor catalog limits, shall be qualified using actual loads and displacements (i.e., not reduced by Rp). This includes, but is not limited to,

- WRC 107 / 297 or more detailed finite element analysis (FEA) shall be performed for nozzle qualification for all vessel nozzles, or other explicit limits provided by the vessel manufacturer shall be met.
- API 610 pump nozzle load limits, or specific manufacturer's limits,
- Seismic interaction assessments, in particular between critical and noncritical piping, and critical piping and other plant structural, mechanical, or electrical features
- Expansion joint end load and deflection limits,
- Vendor catalog support load and deflection limits,
- Valve manufacturer end limits or operator displacement or load limits.

For critical piping, actual loads and displacements shall be obtained from the computer dynamic analyses by specifying Rp = 1 in the input. For noncritical piping using the ASCE 7 Chapter 13 approach, actual loads and displacements shall be obtained by reversing the application of Rp reductions in force and displacement calculations.

<u>Seismic input accelerations:</u>
Dynamic Analysis – For critical piping, the seismic response spectrum input shall be applied simultaneously in three orthogonal directions, with two horizontal directions along the major axes of the model, and one vertical direction:

a) Horizontal: maximum design spectrum determined from ASCE 7 Chapter 11

b) Vertical: defined as 2/3 times maximum horizontal spectrum
c) The input earthquake reduction factor of 0.7 of ASCE 7, 13.1.7 shall not be applied.
d) The input seismic response spectra shall be multiplied by the component importance factor Ip = 1.5 in each direction of application.

Static Analysis, non-critical piping – as specified in ASCE 7 chapters 11 and 13.

Other Analysis Requirements, Critical Piping:
Resultant Loads: Combine all three orthogonal directions of responses by the SRSS (square-root-of-the sum-of the squares) method. Combine individual modal responses by SRSS, except closely spaced modes to be combined absolutely (per 10% spacing criteria),

Included Mass calculation: A sufficient number of modal responses shall be explicitly calculated such that 90% mass participation is achieved in each direction, or missing mass calculations above the frequency cutoff shall be demonstrated to envelope the required project seismic spectrum in the applicable frequency range. In no case shall the frequency cutoff be set to less than 33 Hz,

System damping shall not exceed 5% for any dynamic analysis or determination of seismic input acceleration.

Computer models of seismic supports with gaps not exceeding 1/8 inch total diametral gap may be modeled as linear double acting supports. Single acting supports such as deadweight-only supports or supports with gaps larger than 1/8 inch designed to accommodate thermal expansion must be determined to be active or inactive under seismic loadings based on the status of gap closure or liftoff, and modeled accordingly in the computer analysis. See also Pipe Support design section below.

Static Analysis, Non-Critical Piping:
Static Analysis – Permitted for non-critical piping only, may be performed as per ASCE 7 Chapter 13 “Fp” calculations, provided:

- The vertical acceleration shall be 2/3 horizontal rather than 0.2 g as per ASCE 7, 13.3.1.
- The Chapter 13, section 13.1.7 reduction for allowable stress design (0.7) shall not be applied.
- When nozzle load limits, component deflection limits, or seismic interaction assessments are performed, actual loads and displacements shall be used as specified above.

Allowable stress limits for seismic load combinations for pipe components:

Critical Piping, dynamic analysis with Rp = 1,

a) For components or joints having the B31 or ASME Section 1 stress intensity factor (SIF) > 1.0, allowable seismic stress = 3 x S provided seismic fatigue analysis is performed for 10 cycles of maximum displacement range when intensified stress is greater than yield stress and the resulting seismic partial usage factor is combined with the thermal and operating partial usage factors, such that the cumulative usage factor is less than one for the specified plant life.
b) At locations where the B31 SIF is ≤ 1.0 (e.g., straight pipe and butt welds), allowable stress = 1.2 or 1.33 x S as per the applicable base code occasional

stress limit.

Non-critical piping, static analysis with Rp > 1,

a) Allowable stress = 1.2 or 1.33 x S per applicable Code occasional stress limit.

Piping Load Combinations:

1. Sustained Loads: Dead Load + pressure
2. Operating Loads: Dead load + pressure + temperature (worst case maximum and minimum operating combinations)
3. Occasional Loads: Dead Load + pressure + wind
4. Occasional Loads: Dead load + pressure + seismic Thermal Expansion Loads: Temperature, worst case maximum and minimum design and operating combinations
5. Fatigue: Operating (Dead load + pressure + temperature) (35 year design life) + Seismic fatigue (where required for SIF > 1 locations and intensified stress exceeds yield stress, 10 cycles of maximum displacement range).

Base Load combinations listed above include any live loads, external pressure, impact loads, fluid momentum loads, and reaction forces from pressure reliefs.

The plant minimum design temperature shall not be greater than 32 F. The maximum design temperature shall be determined on a system by system basis in accordance with the final design.

All other good engineering practices for piping system design not delineated explicitly in this section shall be followed as appropriate.

Pipe Support Design:

The following general requirements apply to pipe support design.

1. Pipe supports shall be designed to fully react the loads determined by the design analyses.

2. Seismic loads on seismic restraints shall be considered to act in both + and – directions for each direction of restraint. Pipe support design loads shall be determined by combining sustained and thermal loads algebraically, with seismic loads added absolutely as both positive and negative in order to determine the worst case maximum and minimum loadings for restraint design in each applicable direction

3. For critical piping, pipe support stiffness between the pipe and primary reacting structure or ground shall be determined in each applicable direction of restraint for use in the piping computer analyses. This includes determining the lateral stiffness of U-bolts and clamps, for example, as well as the stiffness of vendor catalog items and supplemental steel used to anchor the support to ground or main building structures.

4. Vendor catalog support items having specified load limits such as struts, clamps, U-bolts, etc. shall be qualified using actual loads for both critical and noncritical piping (i.e., loads not reduced by Rp).

5. One-way acting supports (such as vertical deadweight-only supports or thermal stops)

must be determined to be active or inactive under seismic loadings, and modeled accordingly (i.e., as active or inactive for seismic load cases).

6. Pipe supports intentionally designed with gaps greater than 1/8 inch must be determined to be active or inactive under seismic, and modeled accordingly (i.e., active or inactive for seismic load cases).

7. Seismic restraints having total diametral gaps greater than 1/8 inch that are active in seismic load cases shall have a dynamic load factor of 2 multiplied to the loads determined from the pipe stress analysis if a linear dynamic seismic analysis was performed with no gap (which is generally the case in linear dynamic analyses).

8. Pipe supports that restrain more than one pipe (i.e., gang supports) shall have operating load contributions from individual pipes combined algebraically, with both positive and negative seismic loads (which are unsigned in a linear dynamic modal analysis) from each pipe combined by the SRSS method to determine the total restraining load requirements in each applicable direction.

9. If a response modification factor is used to reduce calculated critical piping loads for the pipe support structural design, the reduction factor used shall be consistent with ASCE 7 design practice, as noted in ASCE 7 chapter 15 Tables 15.4-1 & 15.4-2.

10. For critical piping, the pipe support structural designs shall have stiffnesses that are consistent with assumptions and estimates made in the piping design analyses to ensure that the support deflection under the applied piping loads (which are not reduced by Rp) result in essentially the same displacement as calculated in the piping analysis.

    a. In addition, for critical piping gang supports, the actual support displacement under applied combined loadings from all of the supported pipes shall not differ by a significant and relevant amount compared to the displacements calculated in the the individual pipe stress analyses. If a significant / relevant displacement change occurs under the combined loading, the gang support shall be stiffened sufficiently to meet the pipe stress analysis design assumptions and calculated displacements.

11. Design or as-built deviations in configuration of critical piping system suppirts, including stiffness and resulting displacements, that could significantly change the pipe stress or component load qualification assessments shall be reconciled through appropriate reassessments including reanalysis as necessary consistent with the design basis, and are subject to the approval of NASA.

Design References:

ASME BPVC Sec. I (boilers and boiler piping): [BPVC Sec. I]
ASME BPVC Sec. IV (auxiliary heating boiler): [BPVC Sec. IV]
ASME BPVC Sec. VIII, Div. 1 (other pressure vessels): [BPVC Sec. VIII-D1]
ASME B31.1 – Power Piping: (boiler external piping): [B31.1]
ASME B31.3 – Process Piping: [B31.3]
ASME B31.9 – Building Services Piping: [B31.9]
NFPA 54 (natural gas): [NFPA 54]

Seismic (Ductwork and Plumbing):
Seismic factor (%F=Fp/Wp x 100 as defined in SMACNA page A.1):
Ductwork: %F=0.45 [ASCE Eq.13.3-1: non-welded, sheet metal, max. Z/h=1]
Plumbing: %F=0.43 [ASCE Eq.13.3-1: max. Z/h=10/12]
Seismic Hazard Level (SHL):
Ductwork: SHL=C [SMACNA: Cs ≤ 0.50]
Plumbing: SHL=C [SMACNA: Cs ≤ 0.50]
Design References:
SMACNA Seismic Restraint Manual

Seismic (Fire Protection): per NFPA 13

Wind:
Basic wind speed: 85 MPH [AF]
Exposure: B [AF]
Importance factor: 1.15 [AF]

Safety Factors:
Plant capacity: 1.1 times the SVS design load [PER]
Piping stress: Use allowable stress for appropriate load cases. [ASME]
Pipe support stress (structural elements):
Use allowable stress for appropriate load cases. [ASCE-7]
HVAC loads: None
Select equipment for next available size.
Use filter change-out pressure drop to determine fan performance
Pump and fans: 1.1 x pressure head [MC]

HVAC load calculations: Trane Trace 600
RTS method
Heating load: No credit for occupants or internal heat gain
Report: Input and output, zone peak loads, system peak load, AHU coil selections
Psychometric Analysis (full load and part load): Trane
Other: Excel spreadsheets

HVAC Criteria for Boiler Control Room (N231 Arc Jet Boiler Plant Room 110):
Outside Air Temp. (cooling): 88.2°F DB, 65.9°F WB [ASHRAE 09F:(Moffett Field NAS) 0.4%]
Outside Air Temp. (heating): 36.3°F DB [ASHRAE 09F: (Moffett Field NAS) 99.6%]
Elevation: 33 feet above MSL [ASHRAE 09F: (Moffett Field NAS)]
Room Air Temperature:
Control Room: 72ºF [Peter Chan, CofF Manager]
Control Room: 73ºF-77ºF DB (maximum) [ASHRAE 11A27.3, Table 1: control room]
Control Room: 70ºF-74°F (minimum) [ASHRAE 11A27.3, Table 1: control room]
Night setback (min. 55ºF) and setup control, even if initial occupancy plan is 24-hr
Morning warm-up or cool-down options must be part of the control
Room Humidity: Control of humidity is not required [PC]
Dew point: < 55ºF
Relative humidity (RH%): 30% - 65% [ASHRAE 11A27.3, Table 1: control room]
Relative humidity (RH%): 50% for cooling load calculations [PC]
Humidity Ratio: 0.012 LB/LB maximum [ASHRAE 55-5.2.2]

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Comfort:
- Design occupied DB may be used as operative temperature (as defined in ASHRAE Standard 55) when air speed > 40 FPM, and radiant exchange is not negligible.
- Air speed: < 50 FPM in occupied zone [PC]

HVAC Thermostatic Zoning:
- Single thermostatic zone can be used in control room [PC]

Occupancy:
- Occupants: 4 [MC est.]
- Schedule: 6 AM to 3 PM [PER]
- Schedule profile: Typical low-rise office per CDS [MC est.]
- Heat gain (BTUH): Sensible: 245, Latent: 155 [ASHRAE 09F30.4, Table 1: seated]

Equipment:
- Computers:
  - Clients: 4 (four) Dell Precision 690, 750 W ea. [NC]
  - Servers: 2 (two) Dell Power Edge 750, 280 W ea. [NC]
  - Computer heat gain: [ASHRAE 09F18.12 Table 8: note (a), 90% conv.]
- Monitors:
  - 21” Monitor: 7 (seven) Dell, 1.4 A ea. [NC]
  - 55” LED Monitor: 1 (one) Samsung UN55C8000, 130 W ea. [NC]
  - Monitor heat gain: 90 W [ASHRAE 09F18.12 Table 8 note (c), 60% conv.]
- Ethernet switch: 1 (one) Dell Power Connect 2016, 16 port, 0.4 A ea. [NC]
- Printers: 1 (one) HP 5500 color laser, 7.5 A ea. [NC]
  - Printer heat gain: 110 W (avg) [ASHRAE 09F18.12 Table 9 note (a), 70% conv.]
- PLC rack: 2 (two) AB-7-slot with Logix 5555, 75 W ea. [NC]
- Power Supply: 2 (two) AB 1606-XL, 240 W ea. [NC]
- Fiber converter: 2 (two) Netoptics CV-SX/GCU, 0.6 A [NC]
- UPS: 1 (one) APC SMT2200RM2U, 2500 W ea. [NC]
- Schedule: 6 AM to 3 PM [PER]
- Schedule profile: On [MC est.]

Sound Criteria:
- Control Room HVAC Equipment: NC 40 [ASHRAE 11A27.2, Table 1: control room]
- Install all piping 1” min. from gypsum board.

Ventilation:
- DOAVS (Dedictated Outside Air Ventilation System): Not required. [PC]
- Control Room: 5 CFM per occupant [ASHRAE 62.1] [CMC Table 4-1: Office]
- Control Room: 0.06 CFM/SF [ASHRAE 62.1] [CMC Table 4-1: Office]
- Zone Air Distribution Effectiveness (Ez): 1.0 [CMC Table 4-2: Overhead supply]
- Air movement: Min. 0.75 CFM/SF [ASHRAE 07A3.2, Table 1: Offices]
- DCV (Demand Controlled Ventilation): Not required. Min. OA required for pressurization.
- Condensate reuse consideration: Not practical due to high sensible load ratio
- Economizer control not required. [PC]

Pressurization: Control not required. [PC]
- Control Room: +0.05”WG (positive) relative to outside pressure
- Boiler Area: None [ASHRAE 11A27.4, Table 1]

Filtration:
- Filter: 80% to 95% dust spot [ASHRAE 11A27.2, Table 1: control room]
- Prefilter: MERV-8
- Final filter (upstream of cooling coil): MERV-13
- Filter leakage: < 0.5%
- Filter velocity: ≤ 500 FPM

Local Exhaust:
Control Room: None required.
Occupancy:
Occupants: 4 [MC est.]
Schedule: 6 AM to 3 PM [PER]
Schedule profile: Typical low-rise office per CDS [MC est.]
Heat gain (BTUH): Sensible: 245, Latent: 155 [ASHRAE 09F30.4, Table 1: seated]
Density: 5 OCC/1000SF [CBC Table 4-1: Offices]
Lighting:
Density: 0.9 W/SF maximum allowable
Power: 32 W per lamp (including ballast power) [H. Forteza]
Type: 3-lamp, fluorescent, non-air handling [H. Forteza]
Number: six [H. Forteza]

Existing N231 Building Envelope:
Control Room for Boiler Plant:
First Floor: 5” slab on grade, VT, trenches [as-built]
Finish Ceiling: New 2’x4’ acoustical tile, 8’-0” height [T. Wong]
Wall: 8” concrete block, no insulation, 5/8” gyp X [as-built]
Roof: Built-up asphalt sheet, plywood deck, R-11 batt insulation, 11.5’ height [as-built]
Windows: 1/4” clear single pane, steel casing, overhang, Venetian blinds [as-built]

Existing N231 HVAC Systems:
Heating Water System:
Boiler in N229A [MC survey]
Pump: B&G Model 1531 1-1/4”, 2HP, 1750 RPM in N231 high bay [MC survey]
Chilled Water System: None
Air Handling Unit:
Replace (E) AHU and condensing unit due to age, oversizing and refrigerant

Installation:
Required Clearances:
Manufacturers recommended minimum clearances.
Mechanical equipment 5.0 feet above 100 year flood plain elevation
AHU side clearance: 2’-6” minimum clearance on all sides.
AHU coil service clearance: Coil length + 2’ min.
Install piping and valves so equipment can be isolated for repair.
Install piping & valves so any equipment combination can be used.
Service Access:
Catwalks with stairs: To maintain equipment over 6’ AFF.
Hoist: To lift heavy equipment (>100 lbs.) for maintenance.
Design service areas to preclude hatchways
Design for removal of coils, filters, motors, etc.
Equipment Access: Stairs if access needed more frequently than once a week
Recapitalization: Consider how system will be replaced in future.
Housekeeping pads: 6” thick , and 6” wider than equipment footprint
MER floor drains near equipment served. Avoid extending drain lines into aisles
MCC & disconnect switches: Water lines overhead prohibited. Comply with CEC
Valves over 8’ above floor: Provide chain-operated devices

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Equipment:

Extended Life Expectancy: Provide robust, reliable and energy efficient equipment.

Air Handling Units (AHU):

- Unit construction: Insulated double wall
- Liner exposed to air stream, including inner perforated wall, is prohibited
- SMACNA Seal Class A
- Outdoor intakes: Locate per Interagency Security Committee (ISC) criteria
  - Building <40' tall: Locate intake as high as possible above roof or on wall
  - Minimum air intake separation distance per Table 5-2
- Supply air temperature: 50ºF dewpoint max, 52ºF DB max (DB <50ºF prohibited)
- Fans performance: Tested to ACMA 210
- Fan motor: Select for no overloading on fan curve.
- Fan drives: 1.5 service factor
- Fan bearing: Select for 120,000 hours minimum
- Cooling coils: 6 to 8 rows, 12 FPI max, 500 FPM max face velocity
- Heating coils: 750 FPM max face velocity
- Heating and cooling coils: Copper tubes and copper finned.
- Drain pans: Stainless steel insulated, sloped and trapped.
- Drain pan overflow: Connect to sanitary or storm per code.
- Draw-thru trap: Depth and height between inlet and outlet > FSP+1"WG.
- Filter housing: No exposed lining.
- Filter bank: Differential pressure gauges and sensors.

Motors:

- Motors: per Section 10.4.1 of ASHRAE 90.1, Motors ≥ ½ HP: polyphase.
- Motor selection: Will not overload within expected range of operation
- Motor size safety factor: ≤1 hp=20%, ½ -3 hp=15%, ≥5 hp=10%

Boilers:

- Efficiency per Table 6.8.1F of ASHRAE 90.1
- Gas train per IRI standard

Air Terminal and Distribution Units:

- Layout: ADPI >80% during all full-load and part-load conditions.
- Noise level: Specified background NC per App. A of ASHRAE Standard 113.
- Diffusers: Effectively mix total room air with supply air and adequate ventilation air.

Ductwork:

Duct Sizing:

- CV supply, return and exhaust: Equal friction method using 0.08"WG/100'
- Duct velocity: Main <1500 FPM, Branch <1000 FPM

Supply Air Ducts: Fully ducted supply air to space served.

Return Air Plenum and Ducts:

- Return register: ≤ 2000 CFM
- Return air ducts in floor below roof: Insulate ducts in ceiling plenum.

Ductwork Construction:

- Design and construct supply, return and exhaust air ductwork per:
  - ASHRAE Standard 90.1, Section 6.4.4.2: Ducts and Plenum Leakage
  - ASHRAE Handbook of Fundamentals, Duct Design Chapter
  - ASHRAE HVAC Systems and Equipment Handbook, Duct Construction Chapter;
  - SMACNA HVAC Duct Construction Standards—Metal and Flexible
- Metal thickness, configurations, fittings, reinforcement, construction: per SMACNA
- Flexible Duct:

Flex duct installation:: Per manufacturers' guidelines, ≤ 2 bends
Flex duct length: ≤ 5', distance from hard supply air duct to outlet, +20% max.
Fittings:
Transitions: Smooth per SMACNA standard
Elbows: Centerline radius 1.5 times duct width
Rectangular elbows: Use double foil sound-attenuating turning vanes
Mitered elbows: Not permitted
Duct Sealing:
Seal Class A for all ducts per SMACNA
Seal all joints and connections to AHU's and air distribution devices with mastic:
All supply and return ducts
Seal Tape: Reinforced fiberglass with field-applied mastic and hardcast coating.
Pressure sensitive tape like duct tape or metal tape is not permitted.

Air Distribution System Testing:

Testing after Connections are made to Terminal Units and Air Outlets and Inlets:
DALT supply air and return/exhaust air distribution systems separately
DALT return and exhaust duct under negative pressure
Blank off ends of the ducts airtight
Pressurize supply air distribution system with calibrated fans
Test pressure: Design upstream pressure at terminal units at full flow
Obtain 3 contiguous measures within +/-5% of test pressure at 10-min. intervals
Allowable Leakage Rate: ≤ 5% of design CFM for fan.

Ammonia Storage and Distribution System:

Ammonia used at the SVS Boiler Plant to operate the selective catalytic reactor (SCR) units is a Class III toxic gas and regulated material by the Santa Clara County HazMat Program Ordinance Code (also known as Division B11 of the Santa Clara County Ordinance Code). To satisfy the requirements of the Division B11 Toxic Gas Ordinance, an Ammonia Diffusion Tank (ADT) shall be provided to capture inadvertent release of ammonia from the pressure relief assemblies of the ammonia distribution system. The water inventory in the ADT shall be sufficient to absorb 500 lbs of ammonia and remain below the boiling point of the resulting aqua ammonia solution (to be verified by the ADT vendor). The maximum release rate (TBD) through the tank pressure relief assembly shall dictate the ADT sparger tube size. ADT design shall be per 2010 California Building Code and 2010 California Mechanical Code. The ADT shall have features typical of the ADTs provided by BlueScope Water Solutions, Inc., or equivalent.

No more than 500 lbs and no less than 425 lbs of ammonia shall be stored in a stationary ASME horizontal pressure vessel designed for anhydrous ammonia storage. The ammonia storage tank shall be equipped and instrumented as typical for ammonia service and as necessary to satisfy the Toxic Gas Ordinance (e.g., redundant pressure relief assemblies, excess flow valve, etc.). The tank shall be capable of generating vapor at no less than 50 psig at a rate no less than 8 lbs /hr when ambient temperature is 40 °F or greater. Typical dimensions of a storage tank with this capacity is approximately 65" long and 24" diameter (typical Roy E. Hanson Jr Mfg Model N-120 or equivalent). The ammonia storage tank will not be equipped with a vaporizer, but nozzles shall be provided so that a retrofit would be possible in the future.

The storage tank shall be equipped with nozzles for the following service: fill valve, excess flow

valve for vapor to process, rupture disc/pressure relief valve assembly, fixed liquid level gauge/pressure gauge, liquid level float gauge, and level element with remote readout. There shall be a nozzle on the bottom for an excess flow valve and drain. There shall also be one spare nozzle (top) to facilitate retrofitting a vaporizer to the tank if required in the future. The tank rupture discs shell relieve at 238.5 psi and the PSVs at 265 psi.

The vapor line to the process shall include two isolation block valves, an emergency shutoff valve operated by one of four emergency buttons (one in the control room and three in the field), an operational shutoff valve, a pressure equalizing valve (used during tank filling), a PRV regulating ammonia to the process to 50 psig, and a rupture disc/PSV assembly. The rupture disc/ PSV assembly on the vapor line and the pressure relief assembly on the tank shall vent into a common 1" line that is routed to the ammonia diffusion tank.

The ADT is tentatively a 4' dia X 8' tall tank (nominal 750 gal tank to be verified by tank vendor) initially filled with a minimum of 595 gal of water but no more than 625 gal. The tank shall be carbon steel. All surfaces shall be prepared, primed and appropriate coatings applied.

The ADT shall have the following features as a minimum. Top shall have inspection hatch, a vent cap with screen, and a ammonia inlet (size pending verification of the maximum release rate). Shell shall have drain, manway, and two FNPT couplings for sight glass. There shall also be couplings: two FNPT for temperature instrumentation and one for sample port.

Primary Heating Systems:

Temperature: ≤ 200°F
Total system temperature drop must not exceed 30°F

Hydronic Piping Systems:

- Design and size HVAC piping system per ASHRAE
- Pipe Sizing:
  - Water velocity:
    - General service: 4 fps to 10 fps [ASHRAE 0922.3 Table 6]
    - City water: 3 fps to 7 fps [ASHRAE 0922.3 Table 6]
    - Boiler feed: 6 fps to 15 fps [ASHRAE 0922.3 Table 6]
    - Pump suction and drain lines: 4 fps to 7 fps [ASHRAE 0922.3 Table 6]
  - Pressure friction loss: ≤ 3'WG per 100'
  - Avoid 5" and 1¼" pipe, valves and accessories due to limited availability
- Piping material:
  - Pipe Fittings: Conform to scheduled code
    - Press type, grooved or mechanically formed T type fittings are not acceptable.
- Air Control:
  - Automatic bleed valves:
    - Only accessible spaces in MER, or where seen by maintenance personnel
    - Must be piped directly to open drains
  - Manual bleed valves: Install at terminal units and other less accessible high points
  - Air vents: Provide at all localized high points, and at each heating coil
  - System drains: Provide at all localized low points, and at each heating coil.
- Isolation of Piping at Equipment:
  - Provide shutoff isolation valves, bypass circuits, drain valves, flanges or unions
  - Equipment requiring isolation: Boilers, pumps, coils, heat exchangers.

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Piping System and Equipment Identification:

Identify pipes, valves, and equipment in MER, shafts, ceilings, and other spaces accessible to maintenance personnel
Identify with color-coated piping or color-coded bands, and permanent tags
Identify system type and direction of flow for piping systems
Identify type and number for equipment, per ASHRAE handbooks.
Tag all valves and other operable fittings per ASTM Standard A13.1

Thermal Insulation Systems:

Insulation:
- Fire and smoke-developed index: per CMC [PC]
- Adhesives, mastics, cements, and tapes: per CMC [PC]

Jacketing:
- Metallic jacket: Where subject to damage or reduction in thermal resistivity.
- Metallic jacket: All outdoor piping. [PC]
- Vapor seal (vapor barrier jacket): Enclose insulation subject to becoming wet
- PVC jacketing: Exposed piping
- All-purpose jacketing: Concealed piping.

Duct Insulation:
- Concealed ductwork: Foil face jacketing
- Externally insulate to prevent condensation formation
- Ductboard or internal duct lining is not permitted.

Piping Insulation:
- Insulate all hot water, steam and steam condensate, refrigerant
- Sanitary vents through roof: Insulate 6' below roof line for condensation
- Plumbing piping in plenums or above ceiling: Insulate for condensation
- Insulation for condensation: Must include vapor barrier jackets
- Mechanical Insulation Thickness:
  - Determined by Life Cycle Cost Analysis (LCCA) [PER], and Title 24, whichever is smaller. LCCA Parameters:
    - Economic life: 35 years [PER}
    - UPV (nom): 28.79 [OMB Circular A-94 (2/2011): CA industrial natural gas, 30 yr.]
    - UPV: 33.37 [nominal factor adjusted for 35 year life.]
    - Insulation cost: [WBDG]
    - Material local cost factor: 1.322 [Means: San Jose]
    - Labor local cost factor: 2.386 [Means: San Jose, high security]
    - Boiler duty: 1,504 HRS/YR [PER]
    - Boiler efficiency: 1,180 BTU/LB steam [Nebraska predicted performance, 8/2011]
    - Boiler efficiency: 85.2% [Nebraska performance, 8/2011: based on HHV]
    - Cost of fuel: $10.02/MMBTU [Ivonne Do 8/2008]
    - Insulation thermal conductivity: [mfr data: function of mean temperature]
    - Average ambient: 58.6ºF [worldclimate.com]
    - Average wind speed: 5.3 MPH [ggweather.com]
  - Minimum thickness for personnel protection:
    - Maximum surface temperature: 140ºF [WMIC] [ASHRAE 09F23.3]
    - Minimum thickness: 1" [BAAQMD]
    - Ambient: 86.5ºF [ASHRAE 09F14 Appendix]
    - Wind speed: 0 MPH

Equipment Insulation:

Insulate AHU, pumps, and heat exchangers
Insulate pumps with removable jacketing.
Insulate heat exchangers per ASHRAE Standard 90.1-2007

Noise and Vibration Isolation:
Basic design guides: ASHRAE Applications Handbook
Seal all openings for ducts and piping
Concrete Inertia Bases: Not required. [PC]
Ductwork:
Noise control method: Air velocity, sound attenuators, insulated double-wall ducts
Use acoustical coating or external wrapping to impede fan-generated noise.
Locate volume dampers ≥ 6' from the closest diffuser
Acoustic duct lining: Not permitted in supply air or return air ductwork
Duct connections to equipment with motors or rotating parts: 6" flexible connection
Valve stations, miscellaneous: 85 dB [ASHRAE 11A27.2, Table 1: valve stations]

Meters, Gauges, and Flow Measuring Devices:
Thermometers and Pressure Gauges: Inlet and outlet (or suction and discharge)
Pumps
Boilers
Heat exchangers
Cooling coils
Heating coils
Coils < 10 GPM: Use of portable instruments to check temperatures and pressures
Install test ports at inlet and outlet for use by meters and gauges. [PC]
Duct static pressure gauges: Not required [PC]
Air Flow Measuring Devices: Not required [PC]
Waterflow and Energy Consumption Measuring Devices required: per TSF [PC]

Steam System Piping:
Pressure Piping: Materials, design and installation per ASME B31.3 and ASME B31.1, Section I as listed on drawings.
Pipe Sizing:
Main and SVS Steam (saturated >150 psig):
Velocity: 8,000 to 12,000 FPM (quiet) [ASHRAE 09F22.12]
Velocity: 15,000 FPM max. [ASHRAE 09F22.12]
Velocity: 1,000 to 1,200 FPM per inch ID [Piping Hdbk p20-4]
Pressure Drop: 25 to 30 PSI [ASHRAE 09F22.12, Table 15: 150 PSIG]
Friction Rate: 2 to 10 PSI per 100' [ASHRAE 09F22.12, Table 15: 150 PSIG]
Superheated Steam:
Velocity: 10,000 to 20,000 FPM [Piping Hdbk p20-3, Table 1: >200 psig]
Deaerator and Exhaust Steam (7 psig):
Pressure Drop: 1.5 PSI [ASHRAE 09F22.12, Table 15: 150 PSIG]
Friction Rate: 0.25 PSI per 100' [ASHRAE 09F22.12, Table 15: 150 PSIG]
Flash Steam Vent: 4,000 FPM (2" mini) [ASHRAE 8/91]
Boiler Feed Pump Suction:
Velocity: 3.28 FPS [1 m/s]
Boiler Feed Pump Discharge:
Velocity: 11.48 FPS [Spirax Sarco: 3.5 m/s]
Velocity: 10 to 20 FPS max. [Piping Hdbk p20-33]

Condensate Drain (to trap):
- Length <10m: Size for 200 Pa/m and 1.5 m/s maximum [Spirax Sarco]
- Length >10m: Size for 100 Pa/m and 1.0 m/s maximum [Spirax Sarco]

Condensate Return:
- 7,000 FPM max. vapor velocity [ASHRAE 09F22.20, Table 23, footnote a]
- 1,500 FPM max. liquid velocity [ASHRAE 2/86]
- 10 FPS max. liquid velocity [Piping Hdbk p20-33]
- 6,000 FPM max. vapor velocity [B&G TES-485 p33]
- 1,000 FPM per inch diameter max. vapor velocity [HPAC BES-18]
- Minimum size: 1" or same as trap connection size [B&G TES-485 p33]

Common Return:
- Size : Internal area equal to aggregate area if branches [Spirax Sarco]
- Common riser: Increase one size for common and all branch pipes [Spirax Sarco]

Steam Plant Pipe Installation:
- Slope supply main: 0.25" per 10' min. in direction of steam flow [ASHRAE 08S10.5 #2]
- Slope supply main: 10mm per meter [BSRIA BG 9, Table 6]
- Slope supply branch <10' long: 0.50" per 10' min. toward main [ASHRAE 08S10.5 #7]
- Slope return: 0.50" per 10' min. in direction of condensate flow [ASHRAE 08S10.6 #2]
- Slope trap discharge: 1.5% [Spirax Sarco]
- Boiler steam pipe: Rise 2' to 4' above boiler, drop into header [HPAC 11/01]
- Branch takeoff: From top at 45º (90º acceptable) [ASHRAE 08S10.5 #6]
- Chemical feed pipe: ½" minimum [PY] , ¼ " SS [BSE 1/10]
- Chemical piping and tanks:
  - Obtain county installation permit for hazmat systems [SSCo]
  - Provide secondary containment for hazmat systems [SSCo]
- Deaerator vent: ½" , adjust for 18" to 24" plume [BSE 1/10]
- PRV (Pressure Reducing Valve) Assembly:
  - Tapered concentric reducers [ASHRAE 11/03, p40]
  - Short valve-sized straight pipe at outlet [ASHRAE 11/03, p40]
  - Bypass valve same size as PRV [ASHRAE 11/03, p40]
  - SRV: Size for full port, even if reduced port is used [ASHRAE 11/03, p41]
  - ΔP: 100 psid limit for single valve (150 psid max) [ASHRAE 11/03, p42]
  - Strainer: 100 mesh screen [Spirax Sarco]
  - First elbow: 20D min. downstream from PRV [Hoffman HS-602]
  - Pilot pressure tap:
    - 10D min. downstream from any valve or fitting [Hoffman HS-602]
    - greater of 1m or 15D from fittings [Spirax Sarco]
    - Slope away from PRV actuator [Spirax Sarco]
    - Top of pipe connection (if no slope, then side of pipe) [Sprixa Sarco]
- Include stop valve for isolation [Spirax Sarco]
- Atmospheric vent: Design for 5 psig [Piping Hdbk p20-23]

Steam System Equipment:

Deaerator: Tray and packed column type where height allows [VA DM05]

Feedwater Tank: 20 minutes storage from overflow level at peak output [VA DM05]

Deaerator and feedwater tank: ASME Section VIII-D.1

Boiler Feedwater Pump:
- Non-overloading motor [VA DM05]
- Pump Suction Specific Speed:

Recommended: 8,500 [HI 1.3]
Maximum: 11,000 [HI 1.3]
Suction Head: NPSHa > NPSHr + 2' [ITT]
Blowoff Tank:
Inlet below blowoff header [VA DM05]
Follow Rules and Recommendations for the Design and Construction of Boiler Blowoff Systems [VA DM05]
Maximum discharge 140ºF [VA DM05]
Condensate Trap Assembly:
Size to handle all condensate at reduced pressure conditions [B&G TES-485 p18]
Trap inlet: no less than trap size [Spirax Sarco]
Steam header traps: Size for 10% of boiler load [HPAC 11/01]
Safety Factor: F&T trap = 1.5 to 2.5, IVB traps = 2 to 4 [B&G TES-485 p18]
Location: [ITT TTv13i2]
Ahead of risers
End of mains
Ahead of regulator valves
Maximum riser interval: 20' to 30'
Maximum horizontal interval:
Supervised warm-up: 300' if sloped with steam flow [ASHRAE 08S10.5 #4]
Supervised warm-up: 150' if sloped against steam flow [ASHRAE 08S10.5 #4]
Auto warm-up: Half the interval for supervised warm-up [ASHRAE 08S10.5 #4]
Collecting Leg:
Size: 1.0d [ASHRAE 08S10.5, Fig.4]
Size (supervised warm-up): 0.5d if main >6" (4" min.) [ASHRAE 08S10.5, Fig.4 #8]
Size: 1.0d if main <6", 0.5d if main >5" (4" min.) [BSRIA BG 9, Table 6]
Depth (H): Supervised warm-up = 1.5d (min. 8") [ASHRAE 08S10.5, Fig.4]
Depth (H): Automatic warm-up = 1.0d (min. 28") [ASHRAE 08S10.5, Fig.4]
Volume: <4" = 25%, larger = 25% [ASHRAE 08S11.7 (IDHA 1983): x warm-up load]
Components:
Y-strainer with screen and dirt pocket mounted horizontally [ITT TTv13i2]
Y-strainer screen can be removed after startup, if steam service [NYB Eng Letter A-1]
Install check valve for lifting return lines [B&G TES-485 p18] [ITT TTv13i2]
Use fail-to-open trap to avoid slug accumulation [HPAC 11/01]
Flash Tank:
Vessel: ASME Section VIII-D.1 pressure type [ASHRAE 08S10.15]
Accessories: Steam trap, pressure gage, vacuum breaker, bypass valve, thermostatic air vent, check valve on outlet and all branch inlets, and SRV required [ASHRAE 8/91]
Maximum upward vapor velocity: 10 fps [ASHRAE 08S10.14]
Recommended steam space height: 2' to 3' [ASHRAE 08S10.14]
Minimum steam space volume (CF): 2 seconds [B&G TES-485 p38]
Minimum water space volume (CF): 10 minutes (CFS [B&G TES-485 p39]
Minimum total volume: 2 times intermittent blowdown [National Board]
Minimum vent: 2" [B&G TES-485 p39] thermostatic [ASHRAE 08S10.14]
Inlet: Swing check on each pipe if multiple pipes to tank {ASHRAE 08S10.14]
Boiler:
Boiler Feedwater Limits [ASME Consensus . . , Table 13-2: 451-600 PSIG]::
Total Hardness: 0.200 ppm $CaCO_3$
Iron: 0.030 ppm Fe
Copper: 0.020 ppm Cu

Oxygen: <7 ppb before scavenger
pH: 7.5 to 10
Boiler Water Limits:
Specific conductance: 5000 µmhos/cm [ASME Consensus . , 451-600 PSIG]
Silica: 40 ppm SiO_2 [ASME Consensus . . , Table 13-2: 451-600 PSIG]
Total Alkalinity: 500 ppm $CaCO_3$ [ABMA: 451-600 PSIG]
Total Dissolved Solids (TDS): 2,500 ppm [ABMA: 451-600 PSIG]
Total Suspended Solids: 8 ppm [ABMA: 451-600 PSIG]
Oxygen scavenging:
Sulfite: Distribute 6" to 12" below NOWL [BSE 1/10]
Sulfite residual: 25 to 40 ppm [BSE 1/10] [HPAC 9/99]
Use catalyzed sulfite for rapid oxygen scavenging
Provide dealkalizer if makeup water is >50 ppm [VA DM05]
Condensate TDS: Assume 5 ppm [HPAC 11/85]
Steam Sampling:
Isokinetic Rate: sampling factor x steam flow [HPAC 10/99, Figure 1]
Sampling Factor: 118 / d^2 [HPAC 10/99, Figure 1]
Multi-port Sampling Nozzle: [HPAC 10/99, Figure 2]
Cooler: Reduce sample water to 10ºF over make-up water
Blowdown Heat Recovery:
Reduce sewered water to 20ºF over make-up water [Nalco TF-10 p4]
Safety Relief Valves:
Number: ≥2 [ASME BPVC, Sec 1, PG-67: if >500 ft^2 and >4000 PPH]
Maximum set pressure above MAWP:
Steam boiler:
Single SRV: +0% [ASME BPVC Sec. PG-67.3]
Additional SRV: +3% [ASME BPVC Sec. PG-67.3]
Unfired vessels (deaerator tan, feedwater tank, blowdown tanks):
Single SRV: +0% [ASME BPVC, Sec VIII, UG-134(a)]
Additional SRV: +5% [ASME BPVC, Sec VIII, UG-134(a)]
Additional fire exposure SRV: +10% [ASME BPVC, Sec VIII, UG-134(b)]
Maximum accumulation (overpressure) above MAWP while relieving:
Steam boilers: +6% [ASME BPVC, Sec I, PG-67.2]
Auxiliary HW boiler: +10% [ASME BPVC, Sec IV, HG-400.2(g)]
Unfired vessels (deaerator tan, feedwater tank, blowdown tanks):
Single SRV: greater of +10% or 3 PSIG [ASME BPVC, Sec VIII, UG-125(c)]
Multiple SRV: greater of +16% or 4 PSIG [ASME BPVC, Sec VIII, UG-125(c)1]
Fire exposure: +21% [ASME BPVC, Sec VIII, UG-125(c)2]
Heat exchangers: 0 PSIG [ASME BPVC, Sec VIII, UG-133(d)]
Vent termination: 6' minimum above roof [Piping Hdbk p200-23]
Vent termination: Cut exit on bias to reduce noise
Valves:
Steam (critical): API 598 Triple-offset rotary
Steam (non-critical): Gate valve per listed specification in ASME B31.3, Table 326.1
Connection: Flanged or welded for > 4"

Abbreviations and Reference Notations

[ ] Reference notation
[AF] Azita Firouzi, PE (structural engineer), [AECOM,Code JCE]
[ASCE] American Society of Civil Engineers

[ASME] American Society of Mechanical Engineers
[ASHRAE] American Society of Heating Refrigeration and Air Conditioning Engineers
Handbook reference code: YYVCC.PP where:
YY=last 2 digits of year
V=volume (F=Fundamentals, E=Equipment, A=Applications)
CC=chapter
PP=page
[B&G] Bell and Gossett
[BAAQMD] Bay Area Air Quality Management District
[BPVC] Boiler and Pressure Vessel Code
[BSE] Boiler Systems Engineering
[BSRIA] Business Services Research and Information Association
[CMC] California Mechanical Code
[DALT] Duct Air Leakage Test
DOAS Dedicated outside air system
[HI] Hydraulics Institute
[HPAC] Heating Piping and Air Conditioning Guide
[JB] John Balboni, Code TSF
[MC] Michael Callahan, PE [AECOM, Code JCE]
[Mac] Francis "Mac" McIntosh, Code TSF
[NC] Nick Camarata, AECOM
[NMIC] National Mechanical Insulation Committee - Mechanical Insulation Design
[ITT] ITT Corporation
[NYB] New York Blower
[PC] Peter Chan, CofF Manager
[PER] Preliminary Engineering Report
[PY] Criteria data from Paul Yallouris, PE [AECOM]
[SMACNA] Sheet Metal and Air Conditioning Contractors' National Association
[VA] Veterans Administration

Interdisciplinary Coordination

- Structural: Support for equipment, ductwork and piping. Equipment locations and access clearance, weights, anchor dimensions, and center of gravity; Pipe routing, support location and support design
- Electrical: Power for equipment and controls, conduit for wiring. Equipment locations and access clearance, motor loads, motor voltage.
- Architectural: Reflected ceiling, fire rated separations, access to equipment, noise mitigation. Equipment locations and access clearances
- Civil: Site utilities connections and loads

Project Name:	**Replace Arc Jet Complex SVS Boiler**	
Project No.:	**60212932**	**Issue Date: Dec. 12, 2012**
Discipline Element:	**Mechanical**	

Design Criteria

AECOM

Project Name:	**Replace Arc Jet Complex SVS Boiler**	
Project No.:	**60212932**	**Issue Date: Aug. 24, 2012**
Discipline Element:	**Electrical**	

Hilario Forteza/James McCusker 2.17.12 Preparer / Date	**Fred Jones / Ruslan Nizamov 8.24.12** Reviewer / Date

Objective

Provide electrical design for the Replace Arc Jet Complex Steam Vacuum System (SVS) Boiler project, including site power, lighting, grounding, security system and modification of existing Building N231 power, lighting and tele/data in control room and high bay area.

Prerequisites (Input)

- Identify Required Formats: UFGS specifications, AutoCAD 2008, Revit MEP 2011
- Design Results From Other Disciplines:
  a. Points of connection for utilities from civil engineering
  b. Weather canopy structure and foundations from architect and civil engineer
  c. Mechanical equipment and piping layout by mechanical engineer
  d. Tenant improvement design of control room envelope by architect
- Pertinent Test Data or Analyses Required: None
- Required Test Data For Field Verification: None

Design Elements

- Design Criteria: Established in the PER Construction of Facility (CoF) - FY2013 Program Replace Arc Jet Complex Steam Vacuum System Boiler Preliminary Engineering Report (PER), Document No. A334A-1101-XR2, June 7, 2012.
- Client specifications: Established in PER (Document No. A334A-1101-XR2); Replace Arc Jet Complex Steam Vacuum System Boiler Functional Requirements Document (FRD), Document No. A334A-1101-XR2, June 7, 2012; and TSF Branch Requirements Document No. A334A-1100-XR1, Rev. B, June 30, 2011.
- Codes, Standards and Regulations
  a. California Electrical Code (CEC), 2010
  b. California Energy Code, 2010
  c. NFPA 72, National Fire Alarm Code, 2010
  d. ANSI C80.3, Electrical Metallic Tubing, 2005
  e. ASTM B3, Soft or Annealed Copper Wire, 2001
  f. IEEE 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System, 1983
  g. NEMA 250 Enclosures for electrical equipment, 1000 Volts Maximum, 2008
  h. NEMA PB 1, Panelboards, 2006
  i. NFPA 70E, Standard for Electrical Safety in the workplace, 2009
  j. UL 489, Molded-Case Circuit Breaker & Circuit-Breaker Enclosure, 2009
  k. UL 506, Specialty Transformer, 2008
  l. UL 514A, Metallic Outlet Boxes, 2004
  m. UL 797, Electrical Metallic Tubing, 2007

Project Name:	Replace Arc Jet Complex SVS Boiler	
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- Standard Corporate Protocols:
  a. AECOM CAD Standards
  b. Q4NA-331-GL1, Guidelines for the Preparation of Calculations
  c. Q4NA-331-GL2, Guidelines for the Preparation of Drawings
  d. Q4NA-331-GL3, Guidelines for the Preparation of Specifications
  e. Q3NA-351-FM1, Calculation Review Checklist
  f. Q3NA-351-FM2, Drawing Review Checklist
  g. Q3NA-351-FM3, Specification Review Checklist
- Design Loads
  a. Power and Lighting Load (1739A @ 480V)
- Safety Factors:
  a. Maximum of 25% allowance of the total capacity.
- Design Approach:

  Electrical system shall be designed in accordance with the following general requirements
  a. Lighting power density values: California Energy Code, 2010
  b. Power load: California Electrical Code, 2010
  c. Lighting illumination: Illuminating Engineering Society of North America
  d. Wiring materials and all electrical installations shall conform to the NEC and CEC.
  e. Electrical outlets located outdoors or at other locations exposed to dampness or wetness, shall be protected by ground fault interrupters (GFI's).
  f. Available fault levels within the electrical system will be sufficient to start and operate any electrical load without disrupting operation of other equipment.
  g. Rating of protective equipment will be adequate to detect and isolate electrical faults anywhere within the system.
  h. Voltage drops at normal operating conditions are not to exceed 3%.
  i. The power circuit breakers will be manually operated for non-motor loads. Static trip devices will be furnished on all load center power circuit breakers.
  j. Breaker-protected combination starters or VFD's will control motors fed from MCC.
  k. Work bench areas will be designed to accommodate one separate dedicated branch
  l. Circuit wiring and receptacle for electronic load equipment and another separate wiring and receptacle circuit for convenience load or high impact loads

Equipment Requirement

1. Site Electrical Utilities

(E) Medium Voltage Switchgear: 13.8KV
Utility Transformer (1500 KVA, Pad-Mounted, Oil Filled): 13.8KV- 480Y/277V
Utility Metering System (Primary, Secondary): Primary
Service Voltage (13.8KV, 480Y/277V, 208Y/120V): 480Y/277V
Low Voltage Switchgear: 480Y/277V
Low Voltage MCC: 600V
Low Voltage Distribution Panels: 600V

Project Name:	Replace Arc Jet Complex SVS Boiler	
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Cable Conductive Material: Copper
Medium voltage Cable Insulation System: 15KV, EPR
Low voltage insulation system: 600V, THHN/THWN

2. Site Lighting Distribution System

Arc Jet Boiler Complex Lighting

a. Luminaries Height (Canopy): 35 ft to 40 ft
b. Luminaries Height (Perimeter): 15 ft
c. Luminaries Type (Perimeter): Wall Pack
d. Luminaries Type (Canopy): LED
e. Lamp Type: LED
f. Illumination Level High Bays (Canopy): 20 fc to 30 fc

Site Lighting Control: Toggle switch/Photo Cell and time clock

3. Interior Lighting Distribution System (Control room)

a. Ceiling Height
   i. Control Room: 8 ft
b. Ceiling Type
   i. Control Room: Lay-in
c. Luminaire Type
   i. Control Room: 2x4 Parabolic Fluorescent
d. Lighting Control
   i. Control Room: Dual level switch
e. Lighting level
   i. Control Room: 35 fc, avg. at the work level

4. Building Power Consumption Requirements

a. Lighting Load
   i. Office Area/Control Room: 1.5VA/SF
   ii. High Bay (Canopy): 1.1VA/SF

b. Mechanical Pumps Loads
   iii. Force Draft fan (3 units): 1 @200 HP
   iv. Feed water Pumps (3 units): 1@200 HP
   v. Auxiliary equipment: size TBD

5. Power Distribution System

Primary Utilization Voltage: 480Y/277VAC
Secondary Utilization Voltage: 208Y/120VAC
Voltage Drop Criteria: 3%
Distribution Transformers: Dry type
Primary Neutral Rating: 100%
Secondary Neutral Rating: 100%
Conductor type: Copper
Insulation Type: THHN

Raceway Type

a. Underground Concrete Encased: PVC-schedule 40
b. UG Elbows: PVC-coated RGS
c. Exterior Feeders (Exposed): RGS
d. Interior Feeders (Exposed): EMT

6. Emergency Egress Lighting: Industrial Power Packs
Illumination Intensities comply with NFPA 101
Ballasts
   a. Fluorescent: Electronic
Branch Circuiting (Soft, hardware system): Hardwire

7. Enclosure

Equipment enclosure shall be NEMA classification suitable for environment to which equipment is exposed. Where NEMA 3R enclosure are required in areas exposed to rain, water or high humidity environment. NEMA 4 is rated as weatherproof totally enclosed.

Motor Control Circuit Requirements

1. Where electronically operated controllers are used, motor will be controlled by
   a. "START-STOP" control stations located in sight of and near the motor or,
   b. Automatic devices (such as float switch or limit switch, etc.).

2. A selector switch will be located in sight of and near each motor controlled by an automatic device ("START-STOP" not required). The switch will have three maintain positions labeled HAND-OFF-AUTO, and will provide the following operations:

   a. HAND: Motor can be started manually from a local start control station.
   b. OFF : Motor is stopped and cannot be restarted automatically or manually.
   c. AUTO: Motor is under control of the automatic device

3. Selector switch will have the provisions for padlocking in the OFF position.
4. Control station will be either pushbutton or rotary shaft/rocker arm operated.

Protective Device Requirements

Protective devices will be provided for the electrical system to permit isolation of faulted or overloaded equipment and cables as quickly as possible to minimize equipment damage and limit the extent of system outages. Major components such as the MV switchgear and large transformers will be provided with back-up protection. Current and potential transformers will be connected to provide overlapping zones of protection.

Project Name:	**Replace Arc Jet Complex SVS Boiler**	
Project No.:	**60212932**	**Issue Date: Aug. 24, 2012**
Discipline Element:	**Electrical**	

Grounding System Requirements

a. The grounding system will be designed such that it adequately provides protection against potential hazards associated with rise in voltage and sparks caused by electrical faults, lightning discharges and accumulation of static charges.

b. The grounding system will ensure safety to personnel in relation to touch and step voltages and protect equipment against damage associated with rise of potential.

c. A main ground grid consisting of bare stranded copper cable and compression connections will be provided below grade throughout the SVS Boiler area. Cable riser will be brought above grade from the grid at the site structure. These grounding systems will consist of the conductive metal of approved raceway system, such as conduit and different sizes of bare stranded copper cable.

d. System and equipment grounding shall be in conformance with listed codes. Ground resistance to remote earth shall not exceed 5 ohms as measured by the fall-of-potential method.

e. All major electrical equipment rated 600V and above, such as transformer, switchgear, large motors, motor controllers, etc., will be connected to ground with a minimum of two separate grounding connections.

Lighting Fixture and Receptacle Requirements

a. For selection of lighting fixtures (metal halide or fluorescent and etc.) economic factors will be considered. HPS lamp fixtures will be considered in areas where flood or security lighting is required.

b. In general, suitable rapid start fluorescent fixtures will be used in low ceiling indoor areas requiring high illumination level such as offices, control rooms, etc.

c. Fixtures for general room or area lighting requirements will be symmetrical lens and fluorescent types. For control room, a ceiling metallic grid parabolic system will be provided.

d. Fluorescent fixtures will be utilizing T8 lamps with 3500 degree K temperature and CRI of 80 better. Quite ballasts (sound rated class A) will be used in offices, control room and similar low noise level areas.

e. Use industrial fixtures with metal halide lamps, fluorescent T5 lamps or LED lamps for high bay area.

f. Fluorescent fixtures outdoors or in unheated spaces shall have class P ballast with a temperature of 0 degrees F.

g. Receptacles in Building will be provided, as required, to supply electrical equipment not supplied by permanent wiring and to serve portable electrical devices.

h. Receptacle will be single-phase AC and will have a separate contact for connection to the grounding pole in the plug. Ground contact in plugs and receptacles will be arranged so the grounding circuit is made first and broken last.

i. Branch circuits supplying outlet for general use will have an ampacity not less than the ampere rating of the largest receptacle supplied by the circuit. One circuit will supply not more than six outlets.

j. Ground fault interrupters (GFI) will protect branch circuits supplying outlets for general use.

k. To ensure a reliable, low resistance connection, all wiring terminations to receptacles will be by screw-compression wiring contact. Push-in wiring contact will not be accepted.

l. Welding outlets will be 3 phase, 600V combination of circuit breaker and receptacle type suitable for the service area.

Conduit Requirements

a. Hot-dipped galvanize rigid steel conduit with threaded fittings will be specified where conduit installation is required except as noted below:

- Liquid-tight, PVC jacketed, flexible conduit for all equipment that might be subject to vibrations.
- Schedule 40 PVC pipe sleeve for buried cables.
- EMT conduit for indoor location where is not subject to physical damage and not a wet location.

b. Conduit fills will not exceed the recommendation of the California Electrical Code.
c. A run of conduit will not contain more than the equivalent of four 90 degrees bends between pull boxes, including those immediate at outlets or fitting.
d. The spacing between conduits will be sufficient to allow the installation of locknuts and bushings.
e. Conduits installed outdoors or in high humidity areas where water might enter or condense inside the conduit will be routed into bottom of enclosure. Where conduits must enter the top of enclosures in such areas, conduit seals with drain holes will be provided.

Duct Banks and Buried Conduit Requirements

a. The underground duct banks will be schedule 40 PVC sized 2 inches minimum through 6 inches encased in concrete. A minimum of 4 inches will be maintained between the ducts, and between ducts and edge of duct bank.
b. Below grade conduits must meet the same requirements as provided above grade conduit in addition to the following:

- Sufficient earth cover, concrete encasement, and reinforcement must be provided to prevent damage.
- Manholes and hand holes must be provided to permit pulling cables within their allowable pulling tensions.
- The raceway must be sloped for drainage or water from the ducts towards manholes provided with a sump pit.

Circuit Breaker Requirements

a. Safety is of prime importance in breaker sizing. Loading power circuit breakers close to its 100% rating is not advisable. The circuit breaker will be sized to safely break the circuit under all cases of overload and fault conditions.
b. On new installations, the short circuit capacity of the breakers and bus will take into consideration future system growth. System studies will be conducted to show future system growth capabilities.
c. 600 Volts power circuit breakers are rated at 100% of their long time rating. It is recommended that when sizing a new breaker's feeder it will be sized for 100% of the breaker setting and the initial load is limited to 80%.
d. Phase overcurrent relays or direct acting trip devices are required for all substation main secondary and incoming breakers to provide main bus fault protection. Ground fault overcurrent protection is also required for breaker of substations with low resistance or solidly grounded neutrals.

e. Circuit breakers, switches and contactors whose load side terminals can be energized when in the position from a source outside their own switchgear or control center assembly will be identified by eligible nameplate mounted on the front of their compartment.

Wire and Cable Size Requirements

a. Feeders for busses and power transformers above 600V will be sized to withstand short circuit thermal stress without damage to the feeders. The maximum short circuit level of the supply and clearing time of the feeder protective device will be used to determine this condition. Cable at 600V and below will not be increased in size because of short circuit duty.

b. Motor feeders will have an ampacity not less than 1.25 times the motor full load current and the minimum size will be #12 AWG.

c. Lighting feeder feeding lighting panel will have the ampacity not less than the adjusted maximum demand of the load. The minimum size of branch feeder will be #12 AWG.

d. Cable ampacities will be based on the rated conductor temperature using the applicable tables and derating factors from the CEC. Where the CEC does not cover specific application, such as with certain duct bank configurations, the IEEE/ICEA tables and associated methods of derating cables will be used. Required ampacities will be based on the following loading criteria:

- Transformer feeders
  - 125 percent of maximum transformer rating
- Motor feeders
  - 125 percent of motor full load current
- Feeder to load centers and MCC's
  - 100 percent of full load current plus 25 percent of the largest connected load current
- Other individual load 125 percent of rated full load current feeders

Working Clearance for Substation Equipment

a. Unless greater clearances are specified by CEC, the following minimum clearances will be maintained:

- A minimum working clearance of 3 ft and 6 inches on expose live part.
- A minimum clearance of 3 ft and 6 inches between pad-mounted equipment and fences or walls installed for the purpose of protecting the equipment from unauthorized access.

Communication System Requirements

a. The design of communications facilities including communication conduit, wireways, cables, terminal boards, junction boxes, outlets, and all ancillaries will be provided to meet project specific requirements.

Project Name:	**Replace Arc Jet Complex SVS Boiler**	
Project No.:	**60212932**	**Issue Date: Aug. 24, 2012**
Discipline Element:	**Electrical**	

Interdisciplinary Coordination

- Structural: Equipment locations and access clearance, weights, anchor dimensions, and center of gravity; Pipe routing, support location and support design
- Mechanical: Equipment locations and access clearances
- Architectural: Equipment locations and access clearances
- Civil: Site utilities connections and loads

Design Criteria

AECOM

Project Name:	**Replace Arc Jet Complex SVS Boiler**	
Project No.:	**60212932**	**Issue Date: Dec. 12, 2012**
Discipline Element:	**Instrumentation and Controls**	

Nick Camarata / 12-12-2012 Preparer / Date	**Augie Ermi / 12-12-2012** Reviewer / Date

Objective

Provide instrumentation and controls (I&C) design for the Replace Arc Jet Complex Steam Vacuum System (SVS) Boiler project, including instrument junction boxes and operator workstations to operate the new boilers and ensuring that the controls for the new boiler facility are co-located with the existing Steam Vacuum System controls.

Prerequisites (Input)

- Identify Required Formats: UFGS specifications, AutoCAD 2007
- Design Results From Other Disciplines:
  a. Mechanical flow diagrams, sequence of operation, operating conditions, process data, instrument set points and ranges.
- Pertinent Test Data or Analyses Required: Calibration ranges, alarming and tuning parameters will be developed in conjunction with vendors and other disciplines.
- Required Test Data for Field Verification: The control system will require an Acceptance Test to verify wiring connections, displays and proper operation.

Design Elements

- Design Criteria: Established in the PER Construction of Facility (CoF) - FY2013 Program Replace Arc Jet Complex Steam Vacuum System Boiler Preliminary Engineering Report (PER), Document No. A334A-1101-XR2, June 7, 2012.
- Client specifications: Established in PER (Document No. A334A-1101-XR2); Replace Arc Jet Complex Steam Vacuum System Boiler Functional Requirements Document (FRD), Document No. A334A-1101-XR2, June 7, 2012; and TSF Branch Requirements Document No. A334A-1100-XR1, Rev. B, June 30, 2011.
- Applicable I&C sections from the TSF Branch Requirements Document:
  a. Section 2.1, General User Requirements, Items 10, 12 – 17
  b. Section 2.2, Safety, Items 21 – 24
  c. Section 2.3, Boiler Controls and Electric Power, Items 29 – 31
  d. Section 2.4, Steam Vacuum System Controls, Items 32 – 33
  e. Section 2.5, Maintenance, Item 34
  f. Section 2.7, Start Up, Training and Documentation, Items 40 – 43
  g. Section 2.8, Acceptance Tests, Item 44
- Codes and Regulations
  a. All wiring will be provided in accordance with the National Fire Protection Association NFPA 70 (2011) National Electric Code (NEC).
  b. Control Panels will conform to UL 508, Instrument Control Equipment.
- Standards: Current revisions of ISA standards (formerly ANSI/ISA)
  a. ISA-5.1 (2009), *Instrument Symbols and Identification.*
  b. ISA-5.2 (1992), *Binary Logic Diagrams for Process Operations.*
  c. ISA-5.3 (1983), *Graphic Symbols for Distributed Control/Shared Display*

Instrumentation, Logic and Computer Systems.

d. ISA-5.4 (1991), *Instrument Loop Diagrams*.

e. ISA-5.5 (1985), *Graphic Symbols for Process Displays.*

- Standard Corporate Protocols:
  a. AECOM CAD Standards (2011)
  b. Q4NA-331-GL1, Guidelines for the Preparation of Calculations
  c. Q4NA-331-GL2, Guidelines for the Preparation of Drawings
  d. Q4NA-331-GL3, Guidelines for the Preparation of Specifications
  e. Q3NA-351-FM1, Calculation Review Checklist
  f. Q3NA-351-FM2, Drawing Review Checklist
  g. Q3NA-351-FM3, Specification Review Checklist
- Design Approach:
  a. The existing Boiler and SVS control system are being updated to Allen-Bradley hardware and Rockwell Software. The client wishes the controls for the new boiler project to be co-located with the controls for the existing systems.
  b. Control networks and workstation displays will need to be able to integrate and communicate with the SVS controls, the cooling towers, the new NOx system, and Auxiliary System Controls (water softener, instrument and plant air, boiler chemical feed, auxiliary boiler, and water and steam sampling). Each system or subsystem will be modular to the extent that is practical.
  c. The SVS Steam Plant Controls will provide Supervisory Control and Data Acquisition. An operator will use the SVS Steam Plant Controls to enable/disable the system (e.g. Cooling Tower #1, or to use five stages for the SVS) or adjust the operating point (e.g., desired steam level).
  d. Systems without their own controller will have their data and control signals marshaled to an Instrument Junction Box (IJB), or Remote Input/Output Cabinet (CAB). Systems without their own controllers include the instrument / plant air, boiler chemical feed, auxiliary boiler, blow down / sampling system. These signals will be brought in to I/O modules. Control will be provided by a Balance-Of-Plant controller. This allows the system to be replaced by simply tying the SVS Steam Plant Controls to the new IJB or CAB.
  e. Engineers will be able to use the Data Acquisition system to trend performance metrics from any equipment, or process parameters from any subsystem at an engineering workstation in the N231 Control Room.
- Design Basis:
  a. Boilers will be provided as a package complete with their own controls.
     i. Each boiler will be provided with a ControlNet compatible PLC for the Burner Management System (BMS), and one for the Boiler Combustion Control System (CCS).
     ii. Each boiler package will come with forced draft combustion air and flue gas equipment.
     iii. The I&C design will provide a ControlNet over Ethernet cable to connect the boiler controls to the SVS Steam Plant Controls.
     iv. The design will identify specific parameters that will be communicated between the packaged boiler equipment and the SVS Steam Plant Controls.

b. The new boiler controls will interface with only those SVS controls that have been made available by the SVS Upgrade Project in a cabinet located in the SVS Courtyard.
c. The new boiler controls will interface with other systems or subsystems via control cabinet housing a remote I/O rack and network communications.
d. Interface communication protocols will be ControlNet and Ethernet.
e. All operations will be conducted through the Control Room. If a boiler is to be operated from a field panel, that panel will be authorized from the Control Room.
f. An ammonia delivery system, separate from the boiler package, will be provided. The system consists of an ammonia storage tank and an ammonia diffusion tank, and will provide the required ammonia to the three boilers flue gas stack ventilation systems. Manual emergency buttons will be available in the Control Room and in and around the boiler plant area to provide a warning of a detectable ammonia leak, and to isolate the ammonia tank. Pushing any of the emergency buttons closes the ammonia tank emergency shutoff valve, and triggers audible and visual alarms.
g. Kirk interlock keys for each SVS plenum must be inserted in the key slots on the Boiler Control Panel before the boiler can be lit. The keys are used to lock the plenum hatches after all personnel have cleared the plenums and SVS. The Kirk Keys are available in the old control room, and their function will be replicated in the new control room for the new boiler plant.
h. A video camera system, which includes six cameras, data transmission wiring, a control station, and closed-circuit television (CCTV) monitors, will provide the capability to observe the boiler plant at four boiler plant locations, the N234A Control Room, and the N231 Control Room.

Interdisciplinary Coordination

- Measurement and control instruments will interface with mechanical systems, such as piping, instrument air and the electrical system.
- The architectural discipline will be required to help with the N231 Control Room design.
- Power needs of any electrically activated control items will be coordinated with Electrical.
- I&C will provide heat load and humidity requirements to the Mechanical Discipline to provide for HVAC sizing.
- Accessibility needs will be defined in the 3D BIM model to coordinate space requirements with other disciplines.
- This project will interface with the end-user, Thermophysics Facilities Branch (TSF) of NASA-Ames, who operate the facility and the existing SVS system.
- Reverse Osmosis (RO) project personnel will provide the control algorithm for the three-way control valve that selects between domestic water and RO water. The algorithm will reside on a dedicated controller that is compatible with those currently used by the RO project.