D R A F T

# MASTER
# DESIGN REQUIREMENTS
# Project No. 017144

## CARBON FIBER TECHNOLOGY
## CENTER OFF-SITE

**OAK RIDGE NATIONAL LABORATORY**
**OAK RIDGE, TENNESSEE**

May 2010

**MASTER DESIGN REQUIREMENTS**

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# SECTION 1

# OVERVIEW

1.1 Project Specific Requirements

A. Provide site selection, professional design services and construction services for the Carbon Fiber Technology Facility (CFTC) to meet the requirements described within the Design Requirements.

B. The Carbon Fiber Technology Facility (CFTC) will house a Highly-flexible Carbon Fiber Semi-production Line (CFSL), a Melt Spin Precursor Line (MSPL) and related data acquisition/control hardware for both lines. The CFSL and the MSPL will provide the means of demonstrating and evaluating new low-cost manufacturing processes and technologies for Carbon Fiber Production. The CFSL will be capable of producing various carbon fiber grades and provide the means to evaluate new technologies and the associated cost of production of carbon fiber for multiple applications. The data acquisition and control hardware will require a secured (prox. card access) centralized dedicated control room. The CFTC will also provide adequate space for future installation of Advanced Technology Equipment.

The Developer for the CFTC shall provide a base building facility to house the CFSL, MSPL, data acquisition and control hardware, and the mechanical, electrical, plumbing, piping systems and related office/support space required for the operation of the CFTC as defined the Design Requirements. The Developer is responsible for coordinating with the Company's equipment suppliers to ensure that all building support systems are completely and thoroughly integrated with the systems and equipment provided by the equipment supplier. The Developer is responsible for general building lighting and HVAC systems and sizing all building systems to meet the requirements in this document and the requirements of the CFSL, MSPL, and the data acquisition/control hardware equipment.

The CFSL, MSPL, and the data acquisition and control hardware will be provided and installed by the Company. The Company will contract with an independent equipment supplier specializing in Thermal Conversion Line equipment and Melt Spun Precursor Line equipment. The equipment supplier will be selected by the Company.

Refer to the Specification for "Highly Flexible Carbon Fiber Semi-Production Line Specification No. ORNL-CFTC-2010 CFL01" for information regarding the CFSL.

C. The site for the facility has not been determined. The Developer shall determine the proposed site for the CFTC. The site will require drivable paved service roads for tractor trailer vehicle access and drivable areas for loading and off-loading of trucks (a loading dock is not required). Consideration must be given to maneuvering requirements for tractor trailer vehicles to enter and exit the site. Site lighting shall be provided for security purposes.

1.2 Definitions

A. Authority Having Jurisdiction (AHJ): The organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

B. A-E: The Developers Architect-Engineering firm(s) currently licensed in the state of Tennessee that normally engages in architectural and engineering design work.

C. Certified for Construction (CFC): Contract Documents in compliance with the Design Requirements issued, signed and professionally stamped by the A-E.

D. Company: UT Battelle, LLC.

E. Developer: The firm responsible for providing site selection, professional design services and construction services for the project in accordance with the contract documents and design requirements.

F. Standards:
   1. The Codes, Ordinances, Standards and Regulations that are enforced by the local and state Authorities Having Jurisdiction (AHJ) at the date of issue of the CFC Documents.
   2. Facility development standards, guidelines and restrictions currently enforced for the site that is selected.
   3. Standards/Guides identified for the specific project/discipline defined in each section of the Design Requirements.
   4. If the design requirements conflict with the governing codes and standards, the local governing codes and standards shall take precedence.
   5. In the absence of Codes, Ordinances, Standards/Regulations enforced by a local/state AHJ, the Codes, Ordinances, Standards/Regulations defined or referenced in each project/disciplines section of the Design Requirements shall be the established standard.

1.3 Project Execution

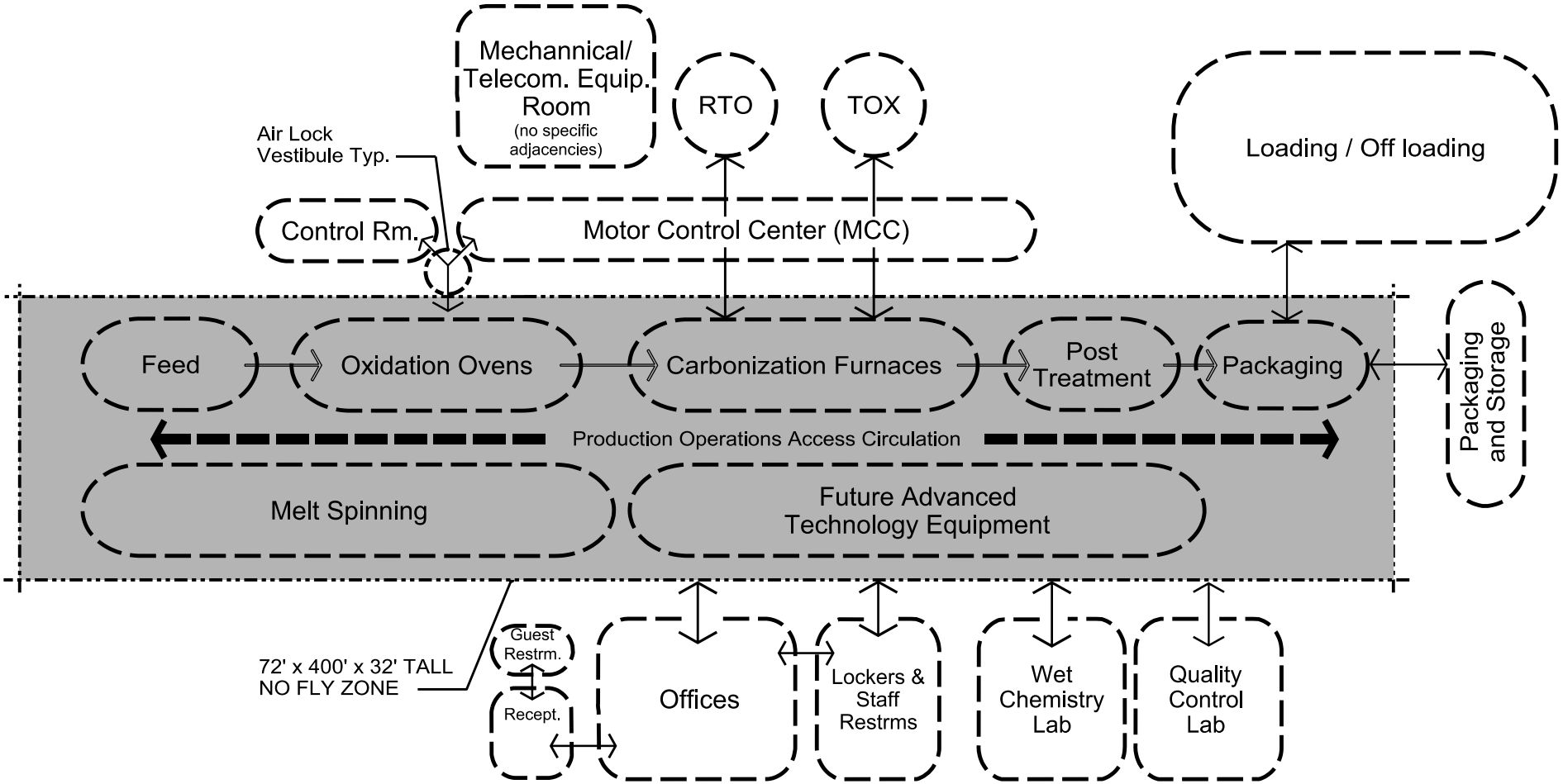
A. Company
   1. The Company will provide project design and construction oversight. As defined in Section 12- Company Interface.

B. Developer
   1. The Developer shall provide site selection, professional design services and construction services for a complete and operational project to meet the criteria defined in the Design Requirements.

C. See Table 1 Space Program Summary, in the room data sheets, for a summary of Company required net usable areas.

D. See Room Data Sheets for detailed program requirements and Usable Square Footage for rooms not listed as Standard Spaces in Section 4 Architectural.
   1. Each space is unique in terms of its utility and space requirements. Net usable areas specified in the room data sheets are minimums and may vary slightly to allow creativity and flexibility in design and layout for achieving a highly efficient building to meet the needs of the facility. Detailed programmatic requirements are provided in the Room Data Sheets and the Architectural section of the Design Requirements.

END OF SECTION 1 OVERVIEW




# Adjacency Diagram

## Carbon Fiber Technology Center

April 26, 2010 Not To Scale

This diagram is not to scale and does not represent or suggest a floor plan or layout of the building. The diagrams' sole purpose is to identify adjacencies required for the functions that are a part of the facility. Additional support spaces will be required such as; electrical, mechanical, or other similar type services that are necessary to support building equipment and production equip.

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D. Company: UT Battelle, LLC.

E. Developer: The firm responsible for providing site selection, professional design services and construction services for the project in accordance with the contract documents and design requirements.

F. Standards:
   1. The Codes, Ordinances, Standards and Regulations that are enforced by the local and state Authorities Having Jurisdiction (AHJ) at the date of issue of the CFC Documents.
   2. Facility development standards, guidelines and restrictions currently enforced for the site that is selected.
   3. Standards/Guides identified for the specific project/discipline defined in each section of the Design Requirements.
   4. If the design requirements conflict with the governing codes and standards, the local governing codes and standards shall take precedence.
   5. In the absence of Codes, Ordinances, Standards/Regulations enforced by a local/state AHJ, the Codes, Ordinances, Standards/Regulations defined or referenced in each project/disciplines section of the Design Requirements shall be the established standard.

1.3 Project Execution

A. Company
   1. The Company will provide project design and construction oversight. As defined in Section 12- Company Interface.

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   1. The Developer shall provide site selection, professional design services and construction services for a complete and operational project to meet the criteria defined in the Design Requirements.

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D. See Room Data Sheets for detailed program requirements and Usable Square Footage for rooms not listed as Standard Spaces in Section 4 Architectural.
   1. Each space is unique in terms of its utility and space requirements. Net usable areas specified in the room data sheets are minimums and may vary slightly to allow creativity and flexibility in design and layout for achieving a highly efficient building to meet the needs of the facility. Detailed programmatic requirements are provided in the Room Data Sheets and the Architectural section of the Design Requirements.

END OF SECTION 1 OVERVIEW

# SECTION 2

# CIVIL

2.1 Project Specific Criteria

A. See Section 1 - Overview.

B. The Civil portion of the project consists of the design and construction of a site sufficient to handle infrastructure for a highly flexible, highly instrumented low-cost carbon fiber technology facility for demonstrating and evaluating new low-cost manufacturing processes and technologies of a Semi-Production Line. Design and construction for the infrastructure on the final site shall be in strict accordance with the requirements set forth in these design requirements as well as in accordance with the local governing codes and standards. If the design requirements which are outlined in this section conflicts with the local governing codes and standards, the local governing codes and standards shall take precedence.

C. The Developer shall be responsible for completing and submitting all applicable local and/or state permits required for the construction of the facility prior to construction activities. The Developer shall also be responsible for all associated permit fees.

D. Drivable paved surface roads and areas shall be provided for semi truck-trailer rigs to access the ends of the facility and to all areas requiring service access to mechanical equipment. Provisions for a parking lot with a minimum capacity of 30 spaces plus code required ADA spaces is required unless the governing code is more stringent. Parking space criteria will utilize the governing zoning ordinance.

E. Preferred site design features for the facility shall include the capability to expand the high bay structure on the one end of the production line that contains the Creel unit. The capability for expansion of the high bay structure shall accommodate approximately a 100 foot long addition which is parallel with the main axis of the production line equipment.

F. A loading dock is not required as a minimum for the facility but may be added at the option of the Developer.

G. All geotechnical investigations and topographic surveys shall be performed for the construction of the facility and shall be the Developer's responsibility.

2.2 Related Sections

A. Section 1 - Overview

B. Section 6- Piping

C. Section 12 - Company Interface.

## 2.3 Design Standards

A. All work shall comply with all local, state and federal laws as well as the governing standards as specified by the Local Authority Having Jurisdiction (AHJ)

## 2.4 Exterior Utilities

A. General
1. Above ground utilities shall be avoided if at all possible
2. Locate new utilities so as to minimize connection costs. Underground utilities shall not be routed under buildings or other permanent structures. If new buildings or other permanent structures are sited over existing underground utilities, then those underground utilities must be relocated. Storm drainage piping must be a parallel distance of at least 10 feet from building foundations. For building foundation setback distances applicable to other types of underground utilities, refer to Section 6 – Piping.
3. When flowable fill is required for trench backfill or other applications, it shall meet the minimum recycled content per the EPA's Comprehensive Procurement Guidelines.
4. Provide coordinate locations for all underground utilities, indicating horizontal and vertical locations of connection points, abrupt changes in direction and system components, as well as enough locations along the lines to clearly establish their location.
5. Tracer wire shall be provided along any non-metallic piping and installed in accordance with the requirements outlined in Section 6 – Piping, of the design requirements documentation.

B. Underground Utilities
1. Sanitary Sewer
   a. Design, installation and testing of the Building Sanitary Sewer shall be in accordance with the Design Criteria for Sewage Works, State of Tennessee and the requirements set forth in Section 6 – Piping, of the design requirements documentation.
   b. Minimum sizes of gravity sewers shall be 6 inch for building connections and 8 inch for all other sewers.
2. Storm Water Management System
   a. The storm water collection and management system shall be designed in accordance with the governing local Stormwater Management ordinances. Any portions of the storm water management system which requires run-off to be channelized and/or piped shall be designed so as to minimize the number of drainage structures required provided the design meets the following criteria.
   b. The total area to be drained shall be considered when analyzing and sizing the storm water system. All runoff shall be controlled and tied to the storm water system, as appropriate.
   c. Provide inlets on roads to reduce spread in accordance with the Tennessee Department of Transportation's (TDOT) Drainage Manual. The spread shall never be more than ½ of a driving lane based on 5-year storm intensity.
   d. In the design of culverts and storm drains, consider headwater and tailwater and their effects on hydraulic grade line and capacity. The hydraulic grade line for the drainage system shall not exceed an elevation one foot above the pipe crown, or

one foot below the structure rim or gutter flow line at inlets, whichever is the lower elevation at each structure.

e. The pipe size must not decrease downstream in the direction of flow. This shall include connections of new collection systems to existing facilities.

f. Provide a minimum flow velocity of 2.5 feet per second and a maximum flow velocity of 10 feet per second using the Manning equation with the pipe flowing full and under no surcharge at peak flow conditions.

g. Locate drainage structures out of paved areas wherever possible. Adjust structure locations to avoid primary wheel tracks when structures must be located in roadways. All drainage structures shall be specified to be in accordance with the TDOT's Standard Specifications for Road and Bridge Construction.

h. The storm drainage system shall not be used for discharging of process or sanitary related waste.

i. Head walls or flared end sections shall be provided at the ends of permanent culverts and at storm drain outfalls unless approved in writing by the Company. Protection from erosion and scouring at head wall and flared end section outfalls shall be provided as needed.

j. Limit maximum velocities and gradients on open channels to prevent erosion on soil type and lining in accordance with the TDOT Drainage Manual.

k. Any storm drain flows which are expected to contain suspended oils shall be routed through an appropriately sized oil/water separator prior to discharge to any outfalls.

l. Where roof drainage is discharged to grade, provide splash blocks/channels to direct the flow away from the structure. Eliminate safety hazards from ice, ponding, flooding etc. in pedestrian and vehicular traffic areas.

m. Where underground collection of roof drainage is used, provide an air break between the downspouts and underground piping.

n. No more than three downspouts shall be collected in a single outlet before connecting to a storm drainage structure, and the length of pipe from the most distant downspout to a drainage structure shall not exceed 150 feet. Provide a cleanout for each downspout connection and the collection header.

o. New material shall be:
   1) Reinforced concrete pipe (RCP) in accordance with ASTM C76/AASHTO M170, Class III, Wall B with bell and spigot joints and gaskets per ASTM C443. RCP shall be used under all roadways.
   2) High Density Polyethylene (HDPE), corrugated with smooth inner wall per AASHTO M-294, and rubber gasket joints per ASTM D3212.
   3) Corrugated Metal Pipe (CMP), AASHTO M36.
   4) Poly Vinyl Chloride (PVC), ANSI/ASTM D3034, Type PSM, SDR-35. Use PVC for storm drains 10 inch and smaller.

p. Wherever practical, all roof drains shall be tied into the storm drain system.

C. Aboveground Utilities

1. Aboveground utilities are to be avoided if possible.
2. Aboveground features shall not be located in front of or in such a manner as to detract from the facility.
3. Maintain a minimum clear height of 23.5 feet at all overhead road crossings.

## 2.5 Sitework

A. Earthwork and Grading

1. Plan facilities to fit the topography with a minimum of grading and to preserve the site character in an efficient and economical manner. Follow all applicable recommendations in the project geotechnical report.
2. Design the site grading in such a way as to balance the earthwork cut and fill quantities.
3. Provide a demolition plan which shows the removal of all surface features, structures and utilities within the footprint of the project.
4. To prevent surface drainage from entering or ponding adjacent to the structure, place finished floor elevations sufficiently above the existing ground gradient or the roadway grade, and slope the outside grade away from the building. A minimum slope of 5 percent shall be provided within a 10 foot distance of the building.
5. Erosion control measures shall be detailed on the design drawings, and shall be in accordance with the TDEC Erosion and Sediment Control Handbook.
   a. The Developer shall generate the project specific SWPPP (Storm Water Pollution Prevention Plan) as required.
6. Eliminate/minimize construction activities which will require permits (i.e. TDEC's ARAP permit).
7. Maximum finish graded slopes shall be 1 unit vertical to 3 units horizontal, unless positive erosion protection is provided, such as rip rap.
8. Coordinate the location of the building with surrounding structures and roads to meet all codes and fire department set back limitations.
9. Permanent seeding will be required on all disturbed areas. Seed mixture shall be a turf type tall fescue.

## 2.6 Sidewalks

A. Contraction and expansion joints shall be provided.

B. Walks shall comply with ADA/UFAS and have a medium to heavy broom finish for slip resistance.

C. Concrete mix shall be 4000 psi minimum with 5%-7% air entrainment to minimize damage due to freeze-thaw cycles and ice melt chemicals. Testing is only required for air entrainment, not strength.

D. Base the width of sidewalks on anticipated traffic, with a minimum width of 4 feet.

E. Sidewalks construction shall be 4 inches thick minimum over a 3 inch base of #57 stone. Sidewalks shall be reinforced with welded wire fabric.

## 2.7 Roads and Parking

A. Design and details for construction of flexible and rigid pavements shall comply with Tennessee Department of Transportation (TDOT), Standard Specification for Road and Bridge Construction, and any recommendations made in the site geotechnical report.

B. Design of parking areas shall include 9 foot wide spaces with 90 degree parking being preferred. All striping shall be 4" wide, white in color except blue for handicap.

C. Parking area circulation must allow for all types of traffic that may be associated with the facility, including deliveries, emergencies and garbage pick-up. Refer to Section 1- Overview for additional details.

D. Clearly indicate turning radii requirements on parking area entrances and islands. If access for fire, maintenance and trash service vehicles is required for the facility and routing through the parking area is necessary, provide layout with turning radii in accordance with the latest edition of the AASHTO publication, A Policy on Geometric Design of Highways and Streets for appropriate design vehicle type.

E. Geometric design and gradients of all roads, streets, access drives and parking areas shall comply with AASHTO - A Policy on Geometric Design of Highways and Streets (GDHS).

F. Design of bridges shall comply with AASHTO LRFD Bridge Design Specifications, US Units, 4$^{th}$ Edition, 2008 Interim Revisions.

G. Road and street grade changes in excess of 1% shall be accomplished by means of vertical curves; the length of vertical curves shall be determined in accordance with AASHTO - GDHS.

H. Roadway centerline gradient profiles shall be shown for vertical control.

I. Positive drainage shall be provided for parking area pavements. Slopes shall be 1% minimum and 4% maximum.

J. Handicap parking allocations shall comply with ADA/UFAS.

K. Concrete curbs and gutters shall be provided for all parking areas.

L. Parking stops shall be manufactured from concrete with a minimum of 20% flyash and shall be anchored to the pavement with rebar. Parking stops shall be provided adjacent to sidewalks without curb, buildings, fences, in areas where part of a vehicle extending past the striped space would likely cause property damage and in areas of extreme slope or areas adjacent to storm management facilities. Locate the front face of the parking stop 30 inches from the edge of pavement or sidewalk.

M. Bollards must be 4 feet high, 4 inch in diameter steel pipe filled with concrete and painted. Provide bollards around any structures subject to damage from vehicular traffic by incidental contact. Ensure that an adequate concrete foundation is designed for the bollard.

N. Traffic control devices shall be in accordance with AASHTO - MUTCD. Provide signs, and associated pavement markings to facilitate proper utilization of the project site (see Section 4 – Architectural, of the design criteria documentation).

O. Flexible pavements shall be used for roadways, access drives, and parking areas. Rigid pavements shall be used for dumpster pads, loading dock aprons, and other pavement areas subjected to high stresses.

P. Pavement systems shall include provisions for under-pavement drainage, if required by the geotechnical report.

2.8 Quality Control and Testing

A. At a minimum, quality control and testing of construction materials and activities shall be performed as recommended in the project's Geotechnical Report, the governing building code and TDOT's Standard Specification for Road and Bridge Construction. The construction documents must contain a list of all required special inspections, field tests, laboratory tests, certifications, documentation and field observations required.

END OF SECTION 2 CIVIL

# SECTION 3

# STRUCTURAL

3.1 Project Specific Criteria

A. See Section 1 – Overview

B. See Section 4 – Architectural

C. See Section 7 – Fire Protection

D. See Section 12 – Company Interface

E. The proposed facility shall be designed in strict conformance with the requirements set forth in these design requirements as well as in accordance with the local governing codes and standards. If the design requirements which are outlined in this section conflicts with the local governing codes and standards, the local governing codes and standards shall take precedence. In the event that no governing building codes have been adopted by the local authority having jurisdiction (AHJ), then the facility shall be designed and constructed in accordance with the 2006 edition of the International Building Code (2006 IBC) and NFPA 101 and all associated referenced standards therein.

F. The basic CFTC Semi-Production Line space shall be approximately 400’ long x 72’ wide with an interior clear bridge crane hook height of 32’-0” (high bay space). In addition, a Motor Control Center Room (MCC) exterior to the main facility shall be provided parallel with the main structure.

G. The structure for the high bay space shall be designed to allow for the future expansion of the facility on the end of the production line which contains the Creel unit. In addition, the structure for the high bay space shall also be designed to accommodate a flexible floor plan layout for equipment, post-installed anchor bolts and interior footings for mezzanine columns.

H. The design criteria listed in this section are minimum requirements. Specific design loads and conditions as provided by equipment vendors may demand designs that exceed the minimum requirements listed herein.

I. All structures required for the access and maintenance of the production equipment (platforms, stairs, railings and walkways) shall be designed and constructed by the Production Line Vendor.

J. Provide a concrete pad for nitrogen gas generation equipment adjacent to the building. This slab shall be designed to support a government furnished 13,000 gallon nitrogen dewer and associated vaporizer.

K. Provide a concrete pad for 10,000 Liter carbon dioxide tank.

L. Provide a concrete pad outside of the facility for the diesel generator.

M. The foundation system and slab-on-grade shall be designed in accordance with the recommendations of the Developer's Geotechnical Report. The slab-on-grade within the high bay space shall consist of a minimum 10" thick heavy industry concrete slab and reinforced with steel reinforcing bars. The slab-on-grade shall be provided with isolated equipment pads for major mechanical equipment. In addition, it is anticipated that service trenches which bisect the slab-on-grade within high bay space will be required.

N. Design of the slab-on-grade within the storage area of the facility shall accommodate material storage racks positioned so as to produce the maximum expected stresses in the slab.

O. Portions of the facility shall be designed to accommodate interior traffic in the form of fork trucks. The design shall include proper considerations for limiting exposure to damage due to impacts. Such features may include some or all of the following measures:
   1. Use of masonry or concrete exterior walls in lieu of metal panels. Alternatively, lower sections of the walls may be composed of masonry or concrete with higher portions composed of metal panels.
   2. Installation of fender posts for columns and walls may be required where speed and size of fork trucks are such that a column or load-bearing wall could be severely damaged or collapse upon impact.
   3. Use of metal guardrails or steel plate adjacent to wall elements.
   4. Curbs.

P. Extraordinary (i.e. low probability) events such as fires, explosions and vehicular impact shall be checked to ensure that structural strength and stability are not compromised when specifically identified and required according to the anticipated use of the facility.

Q. Building Live Loads:
   1. High Bay Area
      a. Uniformly distributed: 250 psf or specific requirements, whichever controls.
      b. Concentrated: 3,000 lbs. acting on an area of 20 square inches or specific equipment weights (i.e. loaded fork trucks, machinery, impact, etc.) whichever controls.
   2. Offices, Office Corridors and Stairs
      a. Uniformly distributed: 100 psf.
      b. Concentrated: 2,000 lbs (stairs shall be 300 lbs. on a tread per IBC)
   3. MEP Equipment Footprint
      a. Uniformly distributed: 150 psf or specific equipment weights.
   4. Roof Live Load
      a. Uniformly distributed: 20 psf (non-reducible) combined with specific supported equipment weights.
      b. Concentrated: 2,000 lbs. or 200 lbs. (refer to paragraph 3.1.N)
   5. Areas designated for light storage
      a. Uniformly distributed: 125 psf
   6. All other spaces
      a. Uniformly distributed: 100 psf or per governing building code.
      b. Concentrated: 2,000 lbs. or per governing building code.

R. Building Collateral / MEP Loads (including suspended ceilings) shall be a uniformly distributed load of 15 psf unless known specific component weights control.

S. The High Bay Area shall be designed to include a 10 ton capacity bridge crane which has coverage over the entire length of the high bay space. Structural design of the bridge crane supports and runway shall be based upon the recommendations provided in Technical Report No. 13, Guide for the Design and Construction of Mill Buildings as published by the Association of Iron and Steel Engineers (AISE TR 13), Specifications No. 70 and 74 as published by the Crane Manufacturer's Association of America (CMAA) as well as Design Guide No. 7 by the American Institute of Steel Construction (AISC DG 7). A CMAA Class B bridge crane or better shall be provided having a pendant control and a maximum speed of 175 feet per minute. The minimum hook height on the bridge crane shall be 32 feet above the finished floor of the high bay space.

T. Any single panel point of the lower chord of exposed roof joists or trusses or any point along the length of exposed primary structural members supporting the roof over the High Bay Area must be capable of safely supporting a suspended concentrated load of 2,000 lbs in addition to the dead and collateral loads. For all other occupancies, a concentrated load of 200 lbs must be used instead of 2,000 lbs.

U. Design of the facility shall include due considerations for design seismic deflections and thermal affects on the structure and thus the need for expansion joints to be included in the structural system.

3.2 Design Standards.

A. All Governing Standards as specified by the Local Authority Having Jurisdiction (AHJ) or as follows in the absence of any such standards:
   1. International Building Code (IBC), 2006.
   2. ASME B30.2, Overhead & Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist).
   3. ASME B30.10-87, Hooks
   4. ASME B30.11, Monorails & Underhung Cranes.
   5. ASME B30.16, Overhead Hoists (Underhung).
   6. ASME B30.17, Overhead & Gantry Cranes (Top Running Bridge, Single Girder, Underhung Hoist).
   7. ASME B30.21, Manually Lever Operated Hoists.
   8. ASME B30.20, Below-the-Hook Lifting Devices.

B. Additional Codes, Standards & Guidelines.
   1. American Institute of Steel Construction (AISC) Design Guide 3, Serviceability Design Considerations for Steel Buildings, Latest Edition.
   2. American Institute of Steel Construction (AISC) Design Guide 7, Industrial Buildings – Roofs to Anchor Rods, Latest Edition.
   3. American Institute of Steel Construction (AISC) Design Guide 11, Floor Vibrations Due to Human Activity.
   4. American National Standards Institute, Standard ANSI Z359.1.

5. Crane Manufacturer's Association of America (CMAA) Specification No. 70, Latest Edition.
6. Crane Manufacturer's Association of America (CMAA) Specification No. 74, Latest Edition.
7. Association of Iron and Steel Engineers (AISE) Technical Report No. 13, 2003.
8. Metal Building Manufacturers Association (MBMA), Metal Building Systems Manual.

3.3 General.

A. The following facility information/classifications shall be denoted on the drawings:
   1. International Building Code (unless specified otherwise by AHJ):
      a. Occupancy Classification: (See Section 7 – Fire Protection)
      b. Construction Type: (See Section 7 – Fire Protection)

B. The facility shall be designed and constructed in accordance with the following:
   1. Wind loads shall be determined based upon the governing building code.
   2. Seismic loads shall be based upon the governing building code.
   3. All structural drawings, specifications, and calculations shall be sealed by a PE licensed in the State of Tennessee.
   4. Floor areas that will serve as corridors for the movement of equipment shall have a minimum live load capacity equal to the largest live load of any room to which they are connected.

3.4 Structural Systems.

A. General.
   1. A description of the structural systems, including the lateral force resisting system, geotechnical parameters, design loads, site class, and seismic design category shall be summarized on the design drawings and any design assumptions (refer to paragraph 3.9).
   2. Any structural feature requiring concrete shall contain a minimum of 20% flyash in the mix, unless performance requirements dictate otherwise.
   3. Walls used to support equipment, cabinetry, etc. shall be designed to safely carry all imposed loads.

B. Foundations.
   1. The building's foundations shall be designed to support all design loads within the allowable soil parameters defined in the Geotechnical Report.
   2. Field testing shall be performed during construction to verify that actual bearing pressure capacities meet or exceed the design values.
   3. Provide waterproofing for all below grade exterior walls and water stops in all construction joints.
      a. Structures with basements shall evaluate the site conditions for the need for a radon removal system in accordance EPA/625/R-92/016 June 1994 – Radon Prevention in the Design and Construction of Schools and Other Large Buildings.

C. Floors - Floor systems shall be designed to carry the intended loads and meet the following provisions:

1. Design of concrete slabs-on-grade shall utilize the subsurface soil parameters defined in the Geotechnical Report. Design of the slab for superimposed distributed loads shall be based upon the maximum expected stresses induced in the slab resulting from non-uniformity of the applied loads. Minimum concrete strength shall be 4000 psi.
2. Concrete under-floor sumps shall be provided as required by the mechanical documents.
3. All concrete floors not receiving epoxy finish or similar floor treatment shall have sealer applied to prevent dusting.
4. Concrete floor slab flatness and levelness shall be specified in the construction documents to meet the intended use of the floors and shall be tested in accordance with ASTM E1155, as required. Remedial action shall be required by the Developer at no cost to the Company if measured F numbers are less than those specified.
5. Elevated floor systems shall be designed to avoid resonant vibration due to human activity as well as mechanical equipment operation (reference AISC Design Guide 11: Floor Vibrations Due to Human Activity). Office floor framing and other similar areas shall be limited to vibratory accelerations of 0.5% g and velocities of 8,000 micro-inches/second. The vibratory accelerations of all laboratory floor systems shall be limited to 0.2% g RMS and velocities of 4,000 micro-inches/second or acceleration limits that will influence specific equipment, whichever controls. As this design criteria generally results in very high quality laboratory spaces, additional measures may still need to be taken for very sensitive equipment or if other vibration sources are encountered. The A-E shall investigate methods that will enhance the vibration characteristics of the floor slab, including but not limited to, the use of localized base isolators provided by equipment vendors. For slab-on-grade applications, the need for any additional geotechnical/site testing required to ascertain and remediate the ambient site vibration characteristics shall be identified and compiled by the A-E into a general requirements document for a vibration study to be performed.

D. Roofs.
1. Secondary (overflow) drainage shall be provided.
2. The roof system shall be designed to support the maximum depth of ponded water assuming the primary drainage system is blocked.
3. Screen walls shall be provided around the perimeter of the structure to hide rood mounted mechanical equipment from view.

E. Concrete
1. Concrete construction must be in accordance with ACI 301.
2. Concrete floors and slabs must be in accordance with ACI 302.1R.
3. Concrete construction tolerances must be in accordance with ACI 117.
4. Epoxy-coated reinforcing steel must be produced in accordance with ASTM A934 in plants certified by the Concrete Reinforcing Steel Institute (CRSI) for fusion-bonded epoxy coatings applied after fabrication.

F. Masonry
1. All masonry design and construction must be in accordance with ACI 530.
2. All concrete masonry must have a specified compressive strength of not less than 1,500 psi.
3. Provide control joints in masonry walls in accordance with NCMA Tek 10-2B or Tek 10-3 and BIA Technical Notes 18A. The structural engineer must coordinate with the

architect to assure that the requirements for masonry control and expansion joints are clearly shown on the construction drawings.

4. Concrete masonry unit foundation walls below grade must be completely filled with grout.
5. Shear walls must use running bond construction.
6. Air spaces, cavities, chases, expansion joints and spaces to be grouted must be kept free from mortar and other debris.
7. Provide anchors and ties for cavity walls. Do not use corrugated metal ties or ties with an integral drip in cavity walls.

G. Structural Steel

1. Structural steel fabrication and erection procedures must be in accordance with AISC Code of Standard Practice.
2. Provide Direct Tension-Indicating (DTI) washers at all bolted connections.
3. All structural steel exposed to weather must be adequately protected to prevent corrosion. All galvanized structural steel must be in accordance with ASTM A123/123M or ASTM A153/A153M, as applicable. Galvanize after fabrication where practical. Repair galvanized coatings using ASTM A780 zinc-rich paint for galvanizing damaged by handling, transporting, cutting, welding or bolting.
4. All weld metal and base metal subjected to cyclic tension must be supplied with “charpy” V-notch testing in accordance with ASTM A6 supplementary requirement SS (5 specimen option). The impact test must meet a minimum average value of 27.1 Joules (20 ft-lbs.) absorbed energy at -18 degrees C (0 degrees F).

H. Steel Joists

1. All steel joist design and construction must be in accordance with the latest standards and specifications of the Steel Joist Institute (SJI).

I. Steel Deck

1. All steel deck design and construction must be in accordance with the latest standards and specifications of the Steel Deck Institute (SDI).
2. Steel form deck must be a minimum of 28 gage in thickness. Roof and composite decks must be a minimum of 20 gage in thickness.
3. At a minimum, all steel deck must be galvanized in accordance with ASTM A 653/653M G60 specifications. For steel deck exposed to spray from salt, salt water, brackish water, or seawater provide ASTM A 653/653M G90 galvanizing.

J. Cold-Formed Steel Framing

1. All cold-formed steel framing design and construction must be in accordance with the latest standards and specifications of the American Iron and Steel Institute (AISI).
2. Design using cold-formed steel studs and joists must comply with the material specifications, nomenclature, section properties and load tables found in SSMA Product Technical information.
3. Minimum thickness of cold-formed steel framing members to be welded must be 16 gage in thickness.
4. All cold-formed steel framed walls must be anchored to foundations with galvanized anchors as needed to resist the design forces. Anchors for exterior walls, interior load bearing walls, and shear walls must not be less than ½ inch diameter embedded anchor

bolts, expansion bolts or adhesive anchor systems with 4 inch embedment spaced at a maximum of 48 inches on center. Anchors for interior non-bearing, non-shearwall partitions must not be less than 3/8 inch diameter embedded anchor bolts, expansion anchors or adhesive anchor systems with 4 inch embedment spaced a maximum of 48 inches on center, or with 0.145 inch diameter powder-actuated fasteners spaced at 24 inches on center.

5. Cold-formed steel members must be connected with screw fasteners or by welding. The use of "pneumatic nailing" is not permitted.
6. For cold-formed steel members exposed to spray from salt, salt water, brackish water, or seawater provide G90 galvanizing and connect with corrosion resistant fasteners.

K. Prefabricated Buildings.

1. Design of the prefabricated building system shall be the responsibility of the building manufacturer.
2. The design and installation of the prefabricated building system shall comply with the MBMA Metal Building Systems manual, and this design criteria.
3. Cables are not permitted as vertical or horizontal bracing.
4. The metal building fabricator must be certified through the AISC Plant Quality Certification Program in the MB category.
5. The structural engineer-of-record must design the building foundation and anchor rod embedment, based on assumed calculated loads or loads provided by a metal building representative. After the metal building supplier submits shop drawings and design analyses for the metal building, the structural engineer-of-record must verify under all loading conditions, the loads imposed by the metal building system onto the foundation and anchor rods do not exceed the design capacity of the foundation system.
6. Due to the relatively high lateral drift allowances for pre-engineered structures in the MBMA specifications, the use of masonry veneers and masonry exterior enclosures must be avoided for metal building systems unless the structural engineer-of-record demonstrates by a relative stiffness analysis that the building displacements and veneer backing displacements will not damage the masonry. Design and construction of masonry veneers must comply with the requirements of ACI 530.
7. Metal building systems must not be attached to existing structures unless the transfer of lateral loads into the existing structures has been accounted for in modifications to the existing structural system.
8. Where additions or interior modifications are to be made to an existing metal building, the new construction must be separated from the existing structure, so that no new loads are applied to the existing framing, unless the metal building was designed for the additional loads, or the Structural Engineer determines by calculation that the existing structure can safely support the superimposed loads.

L. Precast Concrete.

1. The precast concrete plant shall be certified by the Precast/Prestressed Concrete Institute's (PCI) Plant Certification Program prior to the start of production.
2. Manufacturing procedures and tolerances shall comply with PCI MNL-116, Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products.
3. Exposed surfaces shall be free of form lines and other surface blemishes. Inspection and acceptance of the first production units will be required before delivery.

3.5 Serviceability Requirements

A. The maximum allowable live load deflections for the structure shall be as follows (unless specific equipment/user requirements dictate otherwise):

| | | |
|---|---|---|
| 1. | Interior floor beams | span/360 (1 ¼" maximum) |
| 2. | Exterior spandrel beams | span/600 (3/8" maximum) |
| 3. | Roof beams | span/240 |
| 4. | Building lateral drift | height/400 |

3.6 Fall Protection

A. Fall prevention and protection must be considered for the facility whenever there is a need to perform maintenance work or storing of equipment at heights. At the planning and design phase of the project, fall hazards should be considered and eliminated whenever possible. When elimination or prevention of fall hazards is not feasible, the design must include certified and labeled anchorages meeting the requirements of OSHA and the American National Standards Institute, ANSI Z359.1. Where fall protection is required in the vicinity of weight handling equipment, care must be taken to prevent potential conflicts between the weight handling equipment and the fall protection measures.

3.7 Hoists and Cranes.

A. The design, installation and testing for hoists and cranes shall be in accordance with the following:
1. ASME B30.2, Overhead & Gantry Cranes.
2. ASME B30.11, Monorails & Underhung Cranes.
3. ASME B30.16, Overhead Hoists.
4. ASME B30.17, Overhead & Gantry Cranes.
5. ASME B30.21, Manually Lever Operated Hoists.

B. The design of below-the-hook lifting fixtures shall be in accordance with the following:
1. ASME B30.20, Below-the-Hook Lifting Devices.
2. ASME BTH-1, Design of Below-the-Hook Lifting Devices.

END OF SECTION 3 STRUCTURAL

# SECTION 4

# ARCHITECTURAL

## 4.1 Project General Architectural Requirements

A. This project is not located on the ORNL Campus. The project will be located on CROET (Community Reuse Organization of East Tennessee) property. The facility shall be designed with economy of construction as a priority without compromising the goal of providing a quality facility. If this section of the design criteria conflicts with the local governing codes and standards, the local governing codes and standards shall take precedence.

B. Location of the building on the selected site shall respect and cleanly interface with existing roadways to provide convenient access to and from the facility for tractor/trailer combination of 70'-0" with adequate space to maneuver for side and rear loading/offloading adjacent to the high bay roll up door. A loading dock will not be required but may be provided as determined by the Developer.

C. Day lighting shall be maximized to the greatest extent practical in all spaces in the building.

D. Mechanical, electrical or other building or system related equipment located on site that is not enclosed shall be placed so that it will not detract from the aesthetics of the building and shall be located so that they are not visible at the primary entry of the building. Fall protection shall be provided in accordance with OSHA.

E. All exterior entry doors at main entries shall be provided with vestibules to minimize impact on indoor air comfort. A cover shall be provided over all doors with access control (a prox card reader). The card reader for main entries shall be inside the vestibule area, controlling the interior set of doors.

F. Standard Space Requirements (see Table 1: Space Program Summary for sizes and count)
   1. Offices
      a. Office
         1) Finishes
            a) Walls – painted drywall
            b) Floor – carpet
            c) Base – 4" resilient
            d) Ceiling – acoustical tile
         2) Provide two data, two phone outlets and power as defined in the electrical section of the Design Criteria.
         3) Provide minimum 4' by 6' white board
         4) All offices require prox card access
   2. Entry Lobby
      a. Small lobby to accommodate seating for 4-6 persons and receptionist with space for poster and product displays.
         1) Provide built in reception desk (casework)

2) Requires prox card access.
3) Finishes
   a) Walls – painted drywall.
   b) Floor – as selected by developer
   c) Base – 4” rubber
   d) Ceiling – acoustical tile
4) Provide one data, two phone outlets and power at desk and credenza in the floor or wall adjacent to the desk and credenza.
5) Reception Desk shall be provided by the Developer.
6) Furniture shall be provided by the Company.

3. Conference Room
   a. Small Conference to accommodate 10 persons.
      1) Finishes
         a) Walls – painted drywall.
         b) Floor – carpet
         c) Base – 4” rubber
         d) Ceiling – acoustical tile
      2) Provide large marker board with tack strip on top.
      3) Provide minimum of one phone, one data, and 2 duplex power outlets on two walls of the conference room.
      4) Provide minimum 2” conduit and boxes connecting AV cabinet (GFE cabinet) to podium location at front of room.
      5) Provide outlet in ceiling, approximately in the center of the room and 2” conduit access connected to AV cabinet location.
      6) Provide, by Developer, power driven roll down screen proportioned to the room aspect ratio.
      7) AV equipment will be provided as Government Furnished Equipment (GFE), provided and installed by the Company.
      8) Conference room shall be located adjacent the office suite but shall not have direct access from the Entry Lobby.
4. Support Spaces
   a. Small File, Storage, and Fax Room.
      1) Located adjacent to the Offices.
      2) Requires prox card access.
      3) Provide minimum of 1 phone, 1 data, and 4 duplex power outlets.
      4) Finishes
         a) Walls – painted drywall
         b) Floor – resilient tile
         c) Base – 4” rubber
         d) Ceiling – acoustical tile
      5) Aspect ratio should provide most wall lineal footage for lateral filing systems (GFE file cabinets)
   b. Small Copy Room - (enclosed room not required)
      1) Located adjacent to Offices.
      2) Provide minimum of 1 phone, 2 data, and 6 duplex power outlets.
      3) Finishes
         a) Walls – (adjacent hardwalls) – painted drywall
         b) Floor – resilient tile or carpet

c) Base – 4” rubber (adjacent hardwalls)
d) Ceiling – acoustical tile

4) Provide millwork for storage of paper goods for printers. Storage shall include base cabinets and overhead cabinets. All millwork to have laminate finish. Minimum length to be 10’-0”. Provide millwork or shelving to serve as a mail stop for dropping off mail and packages for building occupants.

c. Breakroom for 8 Persons seated at four-seat GFE tables

1) Located near offices and convenient to the production and lab areas.
2) Provide full height partitions for acoustical separation form open offices.
3) Provide minimum of 1wall mounted phone outlet and power outlets for convenience and small appliances at countertop.
4) Finishes
   a) Walls – painted drywall
   b) Floor – resilient tile
   c) Base – 4” rubber (adjacent hardwalls)
   d) Ceiling – acoustical tile
5) Provide millwork with sink with goose-neck faucet. Provide a built-in dishwasher and minimum 13 cubic foot refrigerator and an undercounter ice machine. Counter space for a microwave and a coffee maker is required. Other equipment will be GFE.
6) Provide an area for a minimum of three vending machines – two drink machines and one snack machine.

d. Employee Restrooms – (min. 1 room per sex per floor to meet code requirements)

1) Centrally locate toilet rooms relative to the office work areas.
2) Finishes
   a) Walls – ceramic tile
   b) Floor – ceramic tile
   c) Base – ceramic tile
3) Ceiling – painted drywall

e. Guest Restroom – (provide one unisex visitor restroom)

1) The visitor restroom shall be accessible and shall be equipped with one lavatory and one water closet and the standard toilet accessories.
2) The visitor restroom shall be accessed from the lobby only and shall be arranged to restrict unauthorized personnel from entering other spaces in the building via the guest restroom.
3) Finishes
   a) Walls – ceramic tile
   b) Floor – ceramic tile
   c) Base – ceramic tile
   d) Ceiling – painted drywall

f. Janitors Room – Min. 40 SF

1) Locate Janitors Room adjacent to the Restrooms.
2) Provide 1 floor or service sink with quick disconnect hose attachment.
3) Provide min. 12 linear feet of stainless steel shelving and wall mounted tool rack for mops & brooms etc.
4) Finishes
   a) Walls – painted drywall or CMU
   b) Floor – clear sealer

c) Base – resilient
d) Ceiling – acoustical tile

g. Building Telecommunications Distribution Room – 120 SF
1) Locate to provide most economical service runs to equipment in the building.
2) Provide doors with access control (prox card access).
3) Finishes
a) Walls – painted drywall or CMU
b) Floor – clear sealer
c) Base – 4" rubber
4) Ceiling – acoustical tile
5) Provide aspect ratio for maximum wall space.
6)

h. Mechanical room size as may be required (lockable)
1) Walls – painted drywall
2) Floor – clear sealer
3) Base – 4" rubber
4) Ceilings – open to deck acceptable

G. See Section 7 - Fire Protection for building classification.

H. See Section 1 – Overview for other general requirements.

## 4.2 Standards

A. General Design Standards:
1. Developer shall be responsible for providing a facility designed and constructed in a quality workmanship like manner to meet current industry standards a to provide a secure, structurally sound and weather tight facility.
2. All design and construction shall be in accordance with the local, state and federal codes, ordinances and, regulations enforced by the local and state Authorities Having Jurisdiction (AHJ).
3. If the site selected does not have an AHJ, the facility shall comply with the following:
a. The International Building Code, 2006 (IBC), inclusive of the IBC "Family of Codes"
b. National Fire Protection Association, 2009 (NFPA)
c. Life Safety Code - NFPA 101, 2009
d. Americans with Disabilities Act (ADA), guidelines (ADAAG)
e. "Managing the Risk of Mold in the Construction of Buildings" developed by the Mold Litigation Task Force of the Associated General Contractors of America., Inc.

B. Office Furniture: will be provided and installed by the Company (GFE).

C. Lab Casework: will be provided and installed by the Company (GFE). Lab Casework shall include cabinets, wall mounted cabinets and shelving, countertops, faucets, sinks and tailpieces. Lab casework, casework shall be shown on the plans in the design documents and noted as

GFE. All other casework or millwork shall be provided by the Developer (General Contractor) as part of the construction contract.

D. Signage: Exterior (building identification) and interior signage shall be provided by the Developer.

## 4.3 Material Requirements

A. Exterior Building Materials
   1. Exterior wall materials
      a. Materials shall be as selected by the Developer and the A-E
      b. Materials shall be specified and installed in accordance with current industry standards for commercial construction, and applicable industry/association(s) standards for each particular material.
   2. Materials Restrictions
      a. Materials or components containing asbestos, polycholrinated biphenyl (PCB), CFCs, HCFCs, lead, and carcinogens shall not be utilized in any portion of the design or construction.
      b. Zinc hardware/material shall not be utilized.
      c. Zinc chromate paint shall not be utilized.
      d. Class I refrigerants shall not be utilized.
   3. Doors
      a. Exterior doors shall be a minimum of 3”-0” by 7’-0”.

B. Building Interior
   1. Materials selection
      a. The selection of materials shall be compatible with the architectural concept and the performance requirements outlined in Section 1 – Overview, Section 4 Architectural and Room Data sheets.
      b. Select and install materials that are compatible with the durability requirements of the activities/functions that occur in each room/area and consistent with current construction industry standards/practices for a production or manufacturing facility.
   2. General requirements
      a. The building’s interior organization shall provide functional spaces as established in this Section, Section 1- Overview, and Room Data Sheets of the Design Requirements.
      b. Corridors shall be a minimum of 5’-0” wide.
   3. Partitions
      a. In addition to code locations, offices, restrooms, locker rooms, and laboratories shall have walls extending from the floor to the structural ceiling/slab above and shall be fully insulated for sound.
   4. Doors
      a. Interior doors shall be a minimum of 3’-0” by 7’-0”.
      b. Where interior wood door are used, provide 1¾” thick solid core wood doors unless otherwise required by fire codes.

c. All locksets, including dead bolts, shall be specified to receive Best 7-pin A Series lock cores with master keying by the Company. The Developer shall provide the cores, but the cores will be shipped from Best directly to the Company for keying. Refer to Section 10- Security, for security requirements.

5. Furnishings
   a. Lockers
      1) Lockers shall be minimum 12 inches wide by 15 inches deep by 72 inches high without legs with a sloped top.
      2) Doors shall be vented and have a lockable lift handle.
      3) Provide interior shelf, 3 clothes hooks, and metal number tag.
   b. Shower and Restroom Dividers/Partitions
      1) Shower and Restroom Dividers/Partitions shall be provided for privacy and separation at each shower, water closet, and urinal and as needed for separation of lavatories from toilets/urinals and shower areas.
   c. Toilet accessories
      1) Provide soap dispensers, paper towel dispensers, and paper towel disposal for each pair of sinks as a minimum.
      2) Toilet paper dispensers shall be provided in each stall.
      3) Provide sanitary napkin disposal in each female stall
   d. Interior Finishes: All interior finishes shall be selected by the Developer and the Architect and reviewed by the Company.

END OF SECTION 4 - ARCHITECTURAL

# SECTION 5

# HEATING, VENTILATING AND AIR-CONDITIONING (HVAC)

5.1 Project Specific Requirements

A. Areas/Rooms (CFTC)

1. Production Area:
   The building housing the semi-production line will be larger than the volume allowed for the semi-production line itself with – No air conditioning. The nominal ventilation rate is 7.5 air changes /hour. The equipment temperature limits are 50°F – 113°F. Separate supply and exhaust fan systems are required. Roughing pre-filters on the supply and exhaust fan systems must meet the requirements of Section 5.8.C.5.a.1. Space heaters are required to maintain the minimum space temperature above 65°F.
2. MCC/Electrical Room:
   Room volume is 165 feet x 16 feet x 12 feet. - Conditioned Space. The equipment located in the MCC room temperature limits are 68°F – 80°F. Relative Humidity range is 30-55%. 100% redundant cooling is required. Air handling units to be on standby power; however there is no requirement for UPS. System(s) shall provide heating and ventilation.
3. Wet Chemistry and Quality Control Laboratories:
   Each Laboratory room volume is 500 $ft^2$x 12 feet. - Conditioned Space. The equipment located in these rooms temperature limits are 68°F – 80°F. Relative Humidity range is 30-55%. No redundant cooling is required. Exhaust fans and control system to be on standby power. UPS not required. An 8-feet long fume hood exhaust system is required. Fume exhaust air must meet the requirements of Section 5.8.C.4 for HEPA filters. Each laboratory shall have a stand alone fume hood, space temperature, and pressurization control system that can be interfaced with the Building Automation System (BAS).
4. Production Line Control Room:
   Room volume is 500 $ft^2$ x 12 feet. - Conditioned Space. The equipment temperature limits are 68°F – 80°F. Relative Humidity range is 30-55%. No redundant cooling is required.
5. Office Area:
   Four offices, a conference room, a storage room, copy room and entrance lobby, and a break area are conditioned spaces. The space temperature limits are 68°F – 80°F. Relative Humidity range is 30-55%. No redundant cooling is required. A bypass cooling system utilizing outdoor air for cooling when conditions allow may be used.
6. Facility Support Rooms
   Locker/dressing rooms for men and for women, Mechanical rooms, Janitor Rooms, and all restrooms will be conditioned spaces with no redundancy required. These rooms shall be ventilated in accordance with Section 5.8.A.7. The Building Electrical & Telecommunications Room will also be a conditioned space. The space temperature limits for these rooms are 68°F – 80°F. Relative Humidity range is 30-55%.
7. Packaging and Storage:
   Wire cage areas – no conditioned air, ventilation and heating by production area ventilation and heating systems. Temperature range is 50°F – 113°F.

B. Standards:
1. 10 CFR 434/435, Energy Code for New Federal Commercial and Multi Family High Rise Residential Buildings; Final Rule; dated 10/6/2000.
2. 10 CFR 436, Federal Energy Management and Planning Programs
3. ASME B31.3, Process Piping
4. ASME B31.5, Refrigeration Piping
5. ASME Boiler and Pressure Vessel Code (BPVC) Section VIII
6. ASME N509, Nuclear Power Plant Air Cleaning Units and Components
7. International Building Code, 2006
8. National Fire Protection Association (NFPA) (http://www.nfpa.org )
   a. NFPA 90A, Standard for the Installation of Air Conditioning and Ventilating Systems
   b. NFPA 90B, Standard for the Installation of Warm Air Heating and Air Conditioning Systems
   c. NFPA 91, Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids

C. Additional Standards/Guides
1. Industry Standards and Guides
   a. American Refrigeration Institute (ARI) ( http://www.ari.org/std )
      1) ARI 210/240, Unitary Air-Conditioning and Air-Source Heat Pump Equipment
      2) ARI 310/380, Packaged Terminal Air-Conditioners and Heat Pumps
      3) ARI 340/360, Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment
      4) ARI 365, Commercial and Industrial Unitary Air-Conditioning Condensing Units
      5) ARI 410, Forced-Circulation Air-Cooling and Air-Heating Coils
      6) ARI 430, Central-Station Air-Handling Units
      7) ARI 550/590, Water Chilling Packages Using the Vapor Compression Cycle
      8) ARI 670, Fans and Blowers
      9) ARI 880, Air Terminals
      10) ARI 890, Rating of Air Diffusers and Air Diffuser Assemblies
   b. Air Movement Contractors Association (AMCA) (http://www.amca.org/publications/ )
      1) Publication 201, Fans and Systems
      2) Standard 210, Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
      3) Standard 500-D, Laboratory Methods of Testing Dampers for Rating
      4) Standard 500-L, Laboratory Methods of Testing Louvers for Rating
   c. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) ( http://www.ashrae.org )
      1) Standard 15, Safety Code for Mechanical Refrigeration
      2) Standard 52.1, Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter

3) Standard 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
4) Standard 55, Thermal Environmental Conditions for Human Occupancy
5) Standard 62, Ventilation for Acceptable Indoor Air Quality
6) Standard 90.1, Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings
7) Standard 100, Energy Conservation in Existing Buildings
8) Standard 105, Standard Methods of Measuring and Expressing Building Energy Performance
9) Standard 110, Method of Testing Performance of Laboratory Fume Hoods
10) Standard 111, Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning and Refrigeration Systems
11) Standard 135, BACnet – A Data Communication Protocol for Building Automation and Control Networks
12) Applications Handbook
13) Fundamentals Handbook
14) Refrigeration Handbook
15) Systems and Equipment Handbook
16) Manual, Design of Smoke Control Systems for Buildings
17) Cooling and Heating Load Calculation Manual

d. American Society of Mechanical Engineers (ASME) ( http://www.asme.org )
   1) AG-1a-00, Code on Nuclear Air and Gas Treatment

e. Company's Engineering Standards (http://home.ornl.gov/divisions/engineering/)
   1) ES-5.16-1, Bag-In/Bag-Out High Efficiency Particulate Air Filter System

f. NSF International (NSF) ( http://www.nsf.org )
   1) NSF 49, Class II (Laminar Flow) Biohazard Cabinetry

g. Sheet Metal and Air Conditioning Contractors National Association (SMACNA) ( http://www.smacna.org )
   1) HVAC Duct Construction Standards Metal and Flexible
   2) Rectangular Industrial Duct Construction Standards
   3) Round Industrial Duct Construction Standards

h. Mold Litigation Task Force of the Associated General Contractors of America, Inc. (http://www.abcwestwa.org/ManagingMold.pdf)
   1) Managing the Risk of Mold in the Construction of Buildings

i. ORNL Engineering Standard ES-8-20, Harmonic Limits on Non-Linear loads

## 5.3 HVAC Design Requirements

A. General

1. Equipment specifications shall reflect standard, commercially available equipment that allows a reasonable range of competitive bidding. At least three reputable companies capable of manufacturing the specified equipment shall be identified as potentially acceptable manufacturers for competitive bidding. In addition, manufacturers of major equipment (e.g., boilers and chillers) shall have obtained a satisfactory commercial, industrial record of past equipment experiences before their addition in the specifications as acceptable manufacturers.

2. The specification of electric heating equipment in HVAC systems is prohibited unless justified through a life-cycle cost analysis.
3. HVAC systems and equipment shall meet the minimum energy efficiency requirements of 10CFR434/435 and the latest edition of ASHRAE 90.1, as applicable.
4. Full load and part load energy efficiencies shall be given special consideration in evaluating equipment performance. (Refer to 10CFR434/435).
5. All air conditioning and refrigeration equipment shall comply with applicable ARI standards as a minimum requirement.
6. HVAC equipment shall be sized to satisfy space and/or process heating and cooling load requirements in accordance with the general equipment design and selection criteria contained in the ASHRAE Fundamentals Handbook, ASHRAE Systems and Equipment Handbook, ASHRAE Applications Handbook, and ASHRAE Refrigeration Handbook.
7. Calculations and equipment selection shall be made according to the procedures given in ASHRAE Cooling and Heating Load Calculation Manual and appropriate chapters of the ASHRAE Fundamentals Handbook.
8. Infiltration for heating and cooling design loads shall be calculated according to the methods provided by the ASHRAE Fundamentals handbook.
9. Seismic design and anchorage of mechanical equipment and system components shall be in accordance with Section 3 - Structural.
10. The design and construction of a facility shall follow practices outlined in “Managing the Risks of Mold in the Construction of Buildings”

B. Design Conditions
1. General
   a. Environmental design temperatures and relative humidities for special space uses other than those listed here shall be designated in the project criteria.
   b. The design professional shall verify that the recommended design values are within the criteria bounds of ASHRAE Standard 55 and that the values are in accordance with criteria guidelines in Section 1.
2. Inside Design Temperature and Relative Humidity
   a. When space cooling is required, the inside design temperature to maintain personnel comfort shall be 76 +/- 2°F dry bulb (db) unless otherwise indicated by project criteria. The design relative humidity shall be 55 +/- 5%. Cooling systems shall be designed to maintain space relative humidity conditions through the normal cooling process and should not have controls to limit the maximum relative humidity unless project specific criteria dictate.
   b. The inside wintertime design temperature for personnel comfort shall be 72°F db unless otherwise directed by the project criteria.
   c. Winter humidification for personnel comfort and health shall not be provided unless recordings or engineering computations indicate inside relative humidity levels less than 30%. Where such conditions exist, a design relative humidity of 30% shall be used in establishing minimum humidification equipment requirements.
   d. Ventilation design for general heat relief shall limit the temperature rise of spaces to 10°F maximum above the outside design dry bulb temperature, .
3. Outside Design Temperatures

a. For space personal comfort conditions, the design professional shall size the HVAC system equipment using outside design temperatures otherwise indicated by project criteria. as indicated in ASHRAE Fundamentals Handbook for the Oak Ridge/Knoxville TN area. The winter design temperature shall be the ASHRAE 99% value and the summer design shall be the 1% value.
b. Process designs, i.e. non comfort conditioning applications, shall use the 99.6% and 0.4% ASHRAE winter and summer temperatures respectively.
c. Cooling tower and evaporative condensers sizing shall use the 0.4% mean coincident wet bulb temperatures for design purposes.

C. Mechanical Insulation

1. General Insulation Requirements
   a. All supply and return air ductwork, casings, and air-handling equipment for the air conditioning systems that are not within the conditioned area shall be insulated in accordance with the Company's technical specifications. Minimum thickness for fiberglass duct wrap shall be 1 ½” and other insulating material shall be sized to provide an equivalent insulating value. Additional insulation thickness shall be determined from 10 CFR 434/435 and the life cycle cost analysis.
   b. Insulation inside air handling units (AHUs) shall have a neoprene coating or tightly bonded aluminum on the side exposed to the air.
   c. The AHU housing shall be constructed entirely of double wall galvanized steel (G90) construction with 1-1/2 pound per cubic feet density rigid glass fiber insulation tightly bonded to the panels. Exterior surface finish shall be in accordance with project specific criteria.
   d. Insulation shall be provided for equipment, ductwork, flue pipe and breeching to minimize energy loss, to prevent condensation, and to provide safe surface temperatures.
   e. All insulation material, media used to apply insulation, and jacketing material shall have a maximum flame spread of not more than 25 fuel-contributed and smoke-developed ratings of not over 50 when tested using Underwriters' Laboratories, Inc. (UL) 723, Test Methods.
   f. Asbestos or asbestos-containing materials shall not be used.
   g. Insulation material, thickness, and jacketing shall be designed to provide an exterior skin surface temperature greater than the minimum anticipated ambient dew point for condensation prevention.
2. Refrigerant Piping Insulation
   a. Refrigerant suction lines shall be insulated with closed-cell type rubber tubing insulation, as manufactured by Armaflex or Rubatex Corporation, or its equivalent. Insulation and adhesives used must be the self-extinguishing, fire retardant type.
   b. Minimum insulation thickness shall be 1” and method of application shall be as recommended by the insulation manufacturer.
3. Plant and Equipment Insulation
   a. All hot surfaces within 7 ft of the plant floor or any catwalk shall be insulated to prevent surface temperatures above 130°F where contact would be inadvertent and 120°F where contact is likely or necessary for equipment operation.

D. Fire Protection Requirements

1. General
   a. Fire protection methods must be reviewed and accepted by the Authority Having Jurisdiction (AHJ). Some Section 7 - Fire Protection requirements (fire suppression, fire rated construction, physical separation, etc.) may impact the HVAC system.
   b. See Section 7 - Fire Protection, for comprehensive project specific requirements.
2. Fire Rated Construction
   a. Ductwork shall also be designed to comply with NFPA 90A, including specification and installation of smoke and fire dampers at fire wall penetrations and smoke pressurization/containment dampers as required for smoke pressurization/evacuation systems.
   b. All mechanical and electrical penetrations made into fire rated plenum enclosures shall be fire stopped by listed materials meeting the requirements of ASTM E-814 with a fire rating not less than the rated enclosure.
   c. Fire Dampers
      1) Fire dampers in ductwork shall not be utilized when penetrating the fire rated construction where the ductwork is an integral part of the air filter system equipment that is required to continuously function as part of the confinement system or any system that meets the requirements of NFPA 91.
      2) Duct material penetrating fire rated construction without fire dampers shall be made part of that fire rated construction by either wrapping, spraying, or enclosing the duct with an approved material; or,
      3) Ductwork penetration shall be made part of that fire rated construction by separating the duct material from other parts of the building with equivalent required fire rated construction; or
      4) Ductwork penetration fire rated construction shall be qualified by an engineering analysis in accordance with DOE-STD-1066-99, Appendix D.

## 5.4 Testing, Adjusting and Balancing (TAB)

A. General
1. Test and measuring locations shall be noted on construction drawings. The use of duct mounted airflow monitoring stations shall be considered where limited duct space or configuration restrict the use of pitot tube traverse procedures or where especially sensitive measuring requirements are dictated by the project criteria. All automatic/electronic means of measurement shall be capable of directly communicating with the ORNL campus standard Johnson Controls “Metasys” building management system.
2. Detailed test procedures for the preoperational checkout of the HVAC systems shall be performed in accordance with Section 11 – Commissioning.
3. A listing of the inspections, tests and submittals required by the project specifications shall be prepared and detailed on the Commissioning Agent’s forms and attached to Commissioning Report.
4. Operational startup, testing, and balancing shall not begin until preoperational checkout activities are completed with signatures.

B. Testing and Balancing Devices

1. HVAC air and water distribution systems shall be provided with permanently installed calibrated testing and balancing devices and all water systems shall have permanently installed flow and temperature measuring equipment. Accessibility shall be provided to accurately measure and adjust water or air flows, pressures, or temperatures as required. All permanently installed flow and temperature measurement equipment shall be capable of directing communicating with the ORNL campus standard Johnson Controls "Metasys" building management system.
2. The design professional shall provide as a minimum the balancing devices in Tables 5.1 and 5.2. Test devices shall be located and installed according to the AABC National Standards for Total System Balance 2002.

Table 5.1

Required balancing devices for air distribution systems

| System Components | Required System Devices |
|---|---|
| Diffusers, grilles | Round butterfly or square/rectangular opposed blade volume damper, either registers integral with device or in spin-in take offs |
| Branch ductwork runs | Rectangular/square or round (with more than one opposed blade damper and terminal device). Sealed test hole for pitot tube traverse |
| Fan discharge ductwork | Sealed test holes for pitot tube traverse. Sealed test hole for static pressure measurements |
| Fan suction ductwork | Sealed test hole for static pressure measurement |
| Cooling coil suction and discharge airstreams | Duct-mounted air stream thermometer |
| Heating coil suction and discharge air streams | Duct-mounted air stream thermometer |
| Mixed air plenum air stream | Duct-mounted air stream thermometer |

Table 5.2

Required balancing devices for water and steam distribution systems

| System Components | Required System Devices |
|---|---|
| Chiller evaporator water suction and discharge piping | Thermometer/test well and pressure gage and gage cock |
| Chiller condenser water suction and discharge piping | Same devices as required for chiller evaporator piping |
| Heating or cooling coil (AHU) suction and discharge piping | Thermometer/test well; pressure gage/pressure tap |

| | |
|---|---|
| Heating or cooling coil (AHU) discharge piping | Pre-settable calibrated balancing valve with integral pressure test ports |
| Discharge and Suction piping for reheat coils, fan coil units, unit heaters, ports and finned tube radiation convectors | Pre-settable calibrated balancing valve with integral test ports, temperature test, pressure tap |
| Three-way control valves for suction and discharge piping | Pressure tap |
| Boiler discharge piping | Flow measuring device (orifice or venturi type) |

5.5 Central Cooling and Heating Requirements

A. Plant Equipment

1. Water Chillers

a. The selection of centrifugal, reciprocating, helical, rotary-screw, absorption, or steam powered chillers shall consider coefficients of performance at full load and part load conditions using the energy conservation methods as described in Section 12- Energy and Sustainability.

b. Size, selection, and design shall be based on applicable ASHRAE handbooks and ASHRAE 90.1. Refrigeration equipment shall comply with all applicable ARI Standards, unless otherwise noted. The use of multiple chillers for chilled water loads greater than 400 tons is preferred.

c. Compression refrigeration machines shall be designed with the safety controls and relief devices. Chiller controls shall at a minimum include:

1) High discharge refrigerant pressure cutout switch
2) Low evaporator refrigerant pressure or temperature cutout switch
3) High and low oil pressure switches
4) Chilled water flow interlock switch
5) Condenser water flow interlock switch (on water cooled equipment)
6) Chilled water low temperature cutout switch

d. Refrigeration compressors shall be selected and designed for capacity modulation down to 20% without surge.

e. Selection and specification of equipment shall not allow hot gas bypass control of compressors except when providing capacity modulation below 10% of rated load, if required.

f. Absorption refrigeration machines shall at a minimum be provided with the following safety controls:

1) Condenser water flow switch
2) Chilled water flow switch
3) Evaporation refrigerant level switch
4) Generator high temperature limit switch (gas-fired units)
5) Generator shell bursting disc (high temperature water or steam)
6) Concentration limit controls

g. Liquid coolers (evaporators) shall be designed to meet requirements of ASHRAE Standard 15 and ASME Boiler and Pressure Vessel Code, Sect. VIII.

h. The chiller manufacturer's recommendations regarding appropriate lubricants shall be followed; however, oils containing PCBs will not be permitted.

B. Building Equipment

1. Fans/Motors

a. Fans shall be designed and specified to assure stable, non-pulsing aerodynamic operation in the range of operation over varying speeds. AHUs and fans in sizes over 1 hp shall use belt drives.

b. Fans with motors of 10 hp or less shall be designed with adjustable motor pulley sheaves to assist in air balancing of systems. Fans with motors greater than 10 hp shall use fixed (nonadjustable) drives that can be adjusted by substituting fixed motor pulley sheaves of different diameters.

c. Supply AHUs and return air fans in variable air volume systems shall be designed for control of capacity. Fans shall comply with AMCA Standard 201, ASHRAE Standard 51, and ASHRAE Equipment Handbook.

d. Fans/ductwork interface shall be per the requirements of AMCA Publication 201 and ACGIH Industrial Ventilation Manual. Fan system effect factors shall be determined in accordance with AMCA Publication 201 and added to the static pressure for sizing and selecting fans.

e. Spark resistant construction shall be used where required by NFPA.

f. Generally fan motors 1/2 hp and larger shall be three-phase, 460 V, induction type motors. Totally enclosed fan cooled motors are required for unprotected outdoor locations. Generally, open drip proof motors shall be used indoors and in protected outdoor locations. Across the line starting shall be used for motors 100 hp and smaller. Generally, reduced voltage starting shall be used for motors larger than 100 hp. Variable Speed Drives (VSDs) shall be used wherever a variable volume of air is required. Motors shall be sized to overcome fan inertia at startup and to provide bhp requirements of the load plus drive losses. Motors shall be the premium high efficiency type. Insulation class and temperature rise shall be selected for the ambient temperature at which the motor is to operate at the specified service factor.

g. Centrifugal-type fans with backward inclined or airfoil non-overloading wheels are preferred.

h. Bearings shall have a minimum L-10 life of 80,000 hrs as defined by American National Standards Institute (ANSI)/Anti Friction Bearing Manufacturer's Association Standard II.

i. Bearings shall have fittings for lubrication and relief. Pipe extensions and fittings shall be provided to allow lubrication of equipment without removal of the safety guards.

j. Belt drives shall be designed in accordance with engineering data developed by the drive industry. Designs shall include overload service factors and operating conditions in determining the total percentage above fan motor nameplate horsepower; 140% is a minimum for any application.

1) Safety guards shall be provided in accordance with SMACNA Standards and OSHA requirements to enclose the exposed sides of moving parts, including, but not limited to, couplings, sheaves, shafts, and belts.

2) Tachometer openings with removable covers shall be provided for measuring driver and driven shaft speeds without removing the safety guard.

k. Assemblies shall be dynamically balanced to a minimum of Grade 6.3 per Acoustical Society of America (ASA) S2.19. Special applications requiring especially low vibration levels should be individually evaluated and may require balancing at Grade 2.5 or better per ASA S2.19.

l. Vibration isolation bases shall be provided for rotating equipment. The transmissibility of vibration from rotating equipment on vibration isolators shall generally be limited to 20% for shops, equipment rooms, storage areas, etc., and to 10% for offices, auditoriums, etc. Areas with special requirements for noise and/or vibration control shall be individually evaluated.

2. Air Handling Units

a. The design of air handling equipment and air distribution systems shall optimize both initial cost and air handling system operating and maintenance costs.

b. The design professional shall provide air handling system equipment (fans, terminal units, AHUs, etc.) with vibration isolators and flexible ductwork connectors to minimize transmission of vibration and noise.

c. Systems shall satisfy the noise control levels recommended for various types of spaces and vibration criteria as listed in the ASHRAE handbooks or as specified in the project criteria. Sound attenuation devices shall be installed in the air handling systems if necessary to maintain specified noise levels.

d. Airflow diagrams and system P&ID's shall be developed and provided in the preliminary design phase for each air handling and air distribution system and shall include capacities and locations of fans, coils, filters, terminal devices, and other major air distribution system equipment, as well as airflows and system air pressures and space pressure differentials.

e. Airflow velocities shall be designed to minimize settling of entrained particles as outlined in the ACGIH Industrial Ventilation Manual.

3. Coils - General

a. Heating and cooling coil performance shall comply with and be certified to ARI 410.

b. Cooling coils shall be designed with a maximum face velocity of 500 fpm. Coils shall be specified with drain feature.

c. Air systems with significant percentages of outside air resulting in a mixed air temperature of 35 degrees or less shall be designed with a preheat coil.

d. Preheating coils shall be specified and designed to maintain discharge air temperature without use of integral face and bypass dampers.

e. Coils shall be tested by the manufacturer at 300 psi.

4. Cooling Coils

a. Chilled water, brine, and direct expansion cooling coils shall be certified and rated in accordance with the latest edition of ARI Standard 410. Aluminum fins and copper tubes shall be used. Tubes (1 in. O.D.) shall have a minimum wall thickness of 0.032 in.; 0.625-in. O.D. tubes shall have a minimum wall thickness of 0.024 in. The fin thickness shall be a minimum of 0.009. Coils shall be tested at 300 psig.

b. Cooling coils for spray coil service shall have copper fins to resist corrosion.

c. Water and brine coils shall be provided with accessible plug drains and air vents.

5. Heating Coils

a. Hot water and steam coils shall be rated and certified in accordance with the latest edition of ARI Standard 410. Water heating coils shall have a maximum face velocity of 500 fpm. Steam coils shall have a maximum face velocity of 700 fpm.
b. Hot water coil materials, tube wall, and fin thickness shall be as described above for chilled water coils.
c. Steam coils shall have tube wall thickness of 0.049 in., and fin thickness shall be 0.009 in. Steam coils shall have cupro nickel tubes and headers. Where the coil will be subjected to air at a temperature less than 35°F, it shall be a steam distributing, double tube type with 1 in. O.D. outer tubes; the tubes shall be oriented in a vertical position when practical. For reheat service the coils may be of either the single tube or the steam distributing type unless the specific application requires an even temperature distribution across the face of the coil.

6. Electrical Heating Coils
a. Electrical heating coils shall have low mass, exposed wire heating elements, unless hazardous or corrosive atmospheres require enclosed, finned tube elements.
b. Electrical heating coils shall be protected with automatic and manual reset type snap disc or bulb type safety devices in both the power and control circuits. A sail switch or other airflow sensor shall be interlocked with the fan and a visual alarm. See Section 8, Electrical, for additional information on protective devices.
c. Heating coils operating on 120 and 240 V power shall be controlled by single or multistage line voltage thermostats. Heating coils operated on 480 V power shall be controlled by a temperature sensor coupled with a time proportioning switch, step controller, and electrical contactors, or SCR controller if precise control is required.
d. Controls, such as contactors, step and proportional controllers, time proportioning switches, disconnects, pressure electric switches, SCR controllers, and differential pressure switches, shall be installed in accessible, visible locations outside the duct heater enclosure.
e. Coils shall bear a UL label (preferred) or state that the have been manufactured in compliance with UL design criteria and production requirements, and could bear the UL label if they were assembled with a UL tested and approved contactor and/or with a flow sensing device installed by the duct heater manufacturer."

## 5.6 Decentralized Cooling and Heating

A. Unitary Split Systems
1. Condensers/Condensing Units
a. Water cooled condensers shall comply with and be selected in accordance with ASHRAE Standard 15, ARI 450 and ASME Boiler and Pressure Vessel Code, Sect. VIII.
b. Water cooled condenser shell and tube types shall be designed and specified with removable heads.
c. Air cooled condensers and condensing units shall meet the standards, rating, and testing requirements of ARI 460 and ASHRAE Standard 20. These units shall not be located on roofs unless required by project criteria.

d. The design professional shall locate air cooled condenser intakes away from any obstructions that will restrict the airflow and from locations that receive peak solar heat gain.
e. Air cooled equipment shall be located away from noise sensitive areas, and air cooled condensers shall have refrigerant low head pressure control to maintain satisfactory operation during light loading.
f. The use of once through process or sanitary cooling water is prohibited at ORNL. Use cooling towers, dry coolers, air cooled condensing, etc.

B. Auxiliary Components
1. Heat Generating Equipment
a. A building heat generation system shall not be provided unless one of the following conditions exists:
1) Connection to the central plant distribution system is not cost effective.
2) The central plant has insufficient capacity to accept the building load.
3) The use of the building precludes connection to a potentially interruptible central system.
2. Refrigerant Piping
a. Split refrigeration systems shall have a complete refrigerant diagram prepared on the drawings. The diagram shall include line sizes and approximate location of a refrigerant specialty including access ports/valves, shut off valves, expansion valves, filter dryers, etc.
b. A bill of material, including a description and a manufacturer's catalog number, shall be prepared on the drawing for each refrigerant component.
c. Refrigerant piping shall be sized and configured in accordance with the ASHRAE Refrigeration Manual.

5.7 Air Distribution Systems

A. Ductwork
1. All sizes, materials, construction, and support systems shall be designed in accordance with the ASHRAE handbooks, SMACNA, and Company engineering standards.
2. Ductwork systems shall be designed to meet the leakage rate requirements of Sheet Metal and Air Conditioning Contractors National Association (SMACNA) HVAC Air Duct Leakage Test Manual.
3. The routing of ductwork shall be directed to reduce air resistance unless additional turns would be beneficial in reducing the noise transmission from mechanical equipment or between adjacent rooms of the building.
4. Single-wall, internally insulated ductwork shall not be used.
5. Round elbows shall have a minimum turning radius of 1½ duct diameters.
6. Mitered elbows with turning vanes should be used only where space is limited.
7. The use of computerized duct sizing methods is encouraged to obtain economical designs and the benefits of sizing ductwork by the static regain method.
8. Access doors shall be installed at (1) fire dampers for servicing spring latches and fusible links; (2) both air entering and leaving sides of cooling and heating coils; (3) air entering side of multi-blade balancing dampers; (4) locations requiring periodic inspection, adjustment, and/or maintenance; and (5) locations shown on the drawings.

B. Ductwork Accessories

1. All supply air outlets and return or exhaust intakes shall achieve the specified noise levels in the spaces served. Anti-smudge type air diffusers with fixed cones designed to discharge air horizontally along the ceiling are preferred. Air turning and straightening devices shall be provided for supply air outlets where space is available. Opposed blade volume control dampers shall be provided for supply, return, and exhaust outlets for system balancing.
2. Weather caps shall be constructed in accordance with SMACNA and ASHRAE guidelines.
3. Stacks shall be supported independently of associated equipment.
4. Flexible connections shall be provided between motor driven equipment and the stacks.
5. Instrument test openings shall be provided for Pitot tube traverses in accordance with ASHRAE Standard 111.

C. Terminal Equipment

1. Variable Air Volume Boxes and Fan-Powered Variable Air Volume Boxes
   a. Zone thermostats or temperature sensors and controllers initiate adjustment of a volume-regulating device in the VAV boxes changing the supply airflow rates as required to maintain the space set point temperature.
   b. Reheat coils in the VAV terminal boxes provide perimeter heat.
   c. Calculation of minimum airflow to a zone shall consider minimum ventilation rates in the zone in accordance with ASHRAE guidelines, exhaust air requirements for the zone, and minimum air movement in the zone.
   d. The outside air damper shall be closed during warm up and unoccupied periods.
   e. Specify high entrainment types of outlets to achieve higher air velocity at minimum flow.
   f. Automatic controls should be used in VAV systems to assure a constant/minimum amount of outside air to comply with ventilation codes.

## 5.8 Exhaust, Return and Outside Air Ventilation and Filtration Systems

A. General

1. Design exhaust stack(s) per ASHRAE Fundamentals and to preclude exhaust to intake return of air to a facility.
2. Minimum outside air requirements for ventilated and air conditioned occupied spaces shall be as specified in ASHRAE 62 and the project criteria.
3. Spaces should be maintained under slightly positive pressure with respect to the atmosphere except for toilets, rest rooms, change houses, and similar areas shall be maintained at a negative pressure with respect to adjacent areas. Laboratories and process buildings using hazardous materials may be required to be held at a negative pressure with respect to the atmosphere. These buildings shall be designed for 0.3 in. w.g. negative to their surroundings.
4. Fresh air intakes shall be located where incoming air will be relatively free of exhaust effluent gases and particulates such as grass cuttings and cooling tower drift. Debris screens shall be accessible for cleaning. Intake air velocity shall be less than 500 fpm.
5. Ductwork shall comply with NFPA 91.

6. Ductwork constructed of aluminum should be considered for air exhausted from shower rooms, dishwashing areas, or other areas causing condensation on the duct interior, and have drainage at low points.
7. Rest rooms, janitor closets, garbage rooms, and other malodorous spaces shall be exhausted at a rate of not less than 2 cfm/ft2 or as specified in ASHRAE Standard 62, whichever is the more stringent, regardless of any other calculated ventilation requirements.

B. Return
1. If the indoor air quality does not meet or exceed the limits given in ASHRAE Standard 62, the re-circulated air must be treated and monitored.
2. Areas from which air shall not be recirculated include areas that produce or emit dust particles, heat, odors, fumes, spray, gases, smoke, or other contaminants that cannot be sufficiently treated and could be potentially injurious to health and safety of personnel or are potentially damaging to equipment. These areas shall be 100% exhausted. Project criteria shall indicate other areas of non-recirculation.

C. Particulate Air Filtration
1. Selection of an air cleaning device for a given particulate shall be based on the recommendation of the ASHRAE Equipment Handbook, Sect. I, Chap. II, Industrial Gas Cleaning and Air Pollution Control, and ACGIH Industrial Ventilation Manual.
2. Air cleaning equipment for ductwork installation shall be easily removable, serviceable, and maintainable. Air cleaning equipment shall have face velocities as recommended by the filter manufacturer to achieve maximum efficiency and minimum pressure drop.
3. Filters shall be constructed of noncombustible materials meeting the requirements for UL 900, Class I. Air filters shall be located on the suction side of fans and coils and in other special locations as required for air treatment. Air filter pressure drop gages of the diaphragm actuated, dial type (preferred) or the inclined manometer type shall be located on filter assemblies. Electronic pressure drop sensors shall be provided and shall be capable of direct communication with the ORNL campus standard Johnson Controls Metasys building management system.
4. HEPA filtered systems shall comply with Engineering Standard ES-5.16-1 and as noted in Appendix 5.3 – HEPA Filters.
5. Low Through High Efficiency Filters
   a. All prefilters shall conform to the requirements of ARI 850, Group III Filters and UL 900, Class 1or 2. Prefilter efficiencies for the following filter classifications shall be in accordance with ASHRAE Standard 52.1.
      1) Low efficiency (roughing): 5 to 25%
      2) Medium efficiency: 25 to 75%
      3) High efficiency (not HEPA): 75 to 95%
   b. Prefilters shall be dry fibrous media unless otherwise approved by the Company for specific jobs.
   c. When prefilters are installed to protect HEPA filters, they shall be rated at a minimum of 80 percent efficiency based on ASHRAE 52.1 and shall be UL900, Class 1.
   d. Air filter banks shall be designed for replacement of elements from the air entering side unless otherwise noted.

e. Side loading retainers or other commercially available housings may be used for medium and high efficiency filter systems of up to three filters high by four filters wide.
f. Filter selections shall be based on the lowest efficiency range compatible with the area or system requirements. This does not apply to LEED facilities where MERV 13 filters are required.
g. A photometal tag or other suitable ID tag shall be installed on filter banks.

6. Air-Cleaning Devices for Special Applications
   a. See Appendix 5.4 Special Applications for further information.
   b. Filters such as dry type dust collectors, wet collectors, centrifugal collectors, adsorbers, absorbers, oxidizers, and chemical treatment filters that are used primarily in industrial and process type applications will be described in the project criteria.
   c. Absorbers for nuclear or toxic applications shall comply with ERDA 76-21 and ASME AG-1, Sections FD and FE.

## 5.9 HVAC Control Systems

A. General
1. Special control requirements shall be indicated in the project specific criteria.
2. All control equipment shall be easily accessible. One temperature control panel shall be provided for each system, complete with panel face mounted indicators, switches, pilot lights, and tags. Control interlocks shall be through hands off-automatic (HOA) switches.
3. Control air compressors shall be duplex non-lubricated type with oil lubricated crankcase and distance piece. Air shall be filtered and dried using refrigerated air dryers for dew point of 15°F and regenerative silica type for dew point below 15°F.
4. Copper piping shall be used for high pressure air in inaccessible locations. Transmitters shall be capable of field calibration and thermometers or pressure gages shall be provided at transmitters. Controllers and thermostats shall be pilot bleed type.
5. Instrument and control specifications shall be prepared for each item. A master instrument index shall be used to locate instruments and their respective specifications.
6. Automatic shutoff/on controls with manual override shall be provided where practical.
7. Provisions shall be made for fail safe operation in case of emergency.
8. Control system drawings and specifications shall be detailed sufficiently to allow installation of the entire system by a contractor without additional engineering. Notes shall be shown in a legend on the drawing. Drawings shall include a sequence of operation for each system.

B. Zoning
1. Zoning for automatic control of space temperatures, static pressures, humidities, ventilation, smoke and fire detection, security, and lighting shall satisfy health and safety requirements as indicated in the project criteria, NFPA 101, space operational and occupancy requirements, and zoning exposure with relation to building size, orientation, and configuration.
2. Each HVAC system shall have a separate thermostat for space temperature regulation and a separate humidistat if humidity control is provided.
3. No zone shall contain more than a single building floor regardless of floor space.

4. Automatic controls shall be provided to shut off heating or cooling to any individual zone.
5. Interior zones shall not be combined with external zones.
6. Interior space zones and external zones shall be served by separate equipment.
7. External space zones shall be selected for each individual exposure.
8. For office facilities and similar occupancies, each major orientation shall be zoned to have no more than 2,000 ft2 of floor area with exterior exposure and no more than 3,000 ft2 of floor area without exterior exposure.

C. Control Setback and Shutoff Devices
1. Provide control setback, manual override, and shutoff functions in the Metasys Building Management System, BMS.

D. Humidity Control
1. No controls shall be provided to dehumidify spaces to below 55 +/- 5% relative space humidity or to humidify spaces to greater than 30% relative space humidity unless required on a project specific basis and as stated in the project criteria.

E. Control of Air-Handling Systems
1. Mechanical Ventilation Control
   a. The BMS shall be provided with the feature to control all supply, return, and exhaust ventilation systems to shut off the fan when ventilation is not required.
   b. Systems that circulate air shall be provided with minimum outdoor air damper position control to assure that the minimum outdoor air quantity is being introduced to the system.
   c. Automatic dampers should fail open for return air and fail closed for outside air.
2. Outdoor Cooling Control (Economizer Cycle)
   a. All air handling systems shall be designed to automatically use outside air quantities up to 100% of the fan system capacity for cooling the space, with the exceptions noted in 10CFR434.
   b. The economizer cycle control system shall have a reset feature.
   c. The economizer cycle control system shall be designed with a relief air control cycle to positively relieve the supply air from the space by sequencing return or relief fans or dampers to maintain a constant room static pressure.
   d. Systems using the economizer cycle should be provided with adequate air filtration to handle the quality of the outside air.
3. Automatic Control Dampers
   a. Automatic air control dampers shall be specified to be the low leakage type with a maximum leakage of 6 cfm/ft2 at maximum system velocity of 1500 fpm and 1 in. pressure differential.
   b. The dampers shall be opposed blade type for modulating control.
   c. Dampers shall be sized for at least 20% of the total ductwork resistance pressure drop.
   d. Pilot positioners and operators shall be located out of the airstream.
4. Variable Air Volume System Fan Control
   a. Variable air volume systems shall be designed with control devices to sense ductwork static air pressure and velocity air pressure and control supply fan air

flow and static pressure output through modulation of variable inlet vanes, mechanical speed drive controls, or variable frequency electric drive controls.

b. Exhaust fans, supply fans, and return or relief fans shall have control devices that interface the operation of the fans to "track" air volumes and maintain fixed minimum outdoor air ventilation requirements.

5. Fire and Smoke Detection and Protection Controls
   a. Engineered smoke pressurization and evacuation systems shall comply with the following:
      1) NFPA 90A
      2) NFPA 72
      3) ASHRAE Manual, Design of Smoke Control Systems for Buildings
      4) ASHRAE Systems Handbook
   b. All air handling systems shall be provided with the smoke and fire protection controls required by NFPA 101.
6. Gas Fired Air Handling Unit Control
   a. Gas burner and combustion controls shall comply with Factory Mutual Loss Prevention Data Sheets and be listed in the Factory Mutual Approval Guide. Gas fired AHUs shall be specified with controls to lock out the gas supply in the following conditions:
      1) Main or pilot flame failure
      2) Unsafe discharge temperature (high-limit)
      3) High or low gas pressure
      4) No proof of air flow over heat exchanger
      5) Combustion air loss
      6) Loss of control system actuating energy
7. Control of Chilled Water and Hot Water Distribution Systems
   a. Zone Control/Distribution System Control
      1) Each zone or air handling system shall be designed with individual terminal unit valve control.
   b. Control Valve Selection
      1) Temperature control valves shall be either two-way or three-way, two position or proportioning type valves. Valves controlling modulation shall be equal-percentage proportioning valves.
      2) Control valves shall be sized for a 5 psi pressure differential across the valve or a pressure differential of 50% of the combined branch piping and coil pressure drop, whichever is greater.
      3) Control valves shall use either pneumatic, electric, electronic, or self contained controllers.
      4) Valves in cooling and heating systems shall be fail safe.
      5) Valve operators shall be selected to close against pump shutoff head for two way valves and one half pump shut off head for three way valves.
      6) Setpoints shall be selected to maintain either a fixed space temperature or a fixed coil discharge temperature.
   c. Load Control for Hot Water Systems
      1) The supply delivery temperature shall be reset based on the temperature outside.
   d. Load Control for Chilled Water Systems

1) Central station cooling equipment shall modulate to control capacity.
2) Central station cooling equipment shall be provided with controls to limit the current draw of the cooling equipment in periods of high electrical demand.

F. Building Management Systems (BMS) and Direct Digital Control (DDC) System

1. Design basis shall be Johnson Controls, Inc. (JCI) controls equipment compatible with the Metasys BMS.
2. Design documents shall require the system supplied to communicate with the current ORNL campus wide BMS's, JCI Metasys M5 from the ORNL intranet.
3. Design shall specify BACNet Level 4 (web based) compliant DDC equipment, compatible interface devices and programming to access and control the BMS from remote workstations with approved web browsers and connection to the ORNL intranet (Ethernet) system.
4. The design professional shall design permanent metering when required in accordance with 10 CFR 434 or the project specific criteria in Section 5.1.
5. Permanent sub-metering shall be considered and implemented for each type of process energy consumed in new buildings and facilities owned and leased by DOE as indicated in the project criteria.
6. Control software shall include Optimum Start/Stop, Scheduled Start/Stop, Night Purge, Night Setback, Chiller Optimization, Tower Optimization, and Chilled Water Reset.
7. The BMS/DDC system shall not interfere with or override any safety feature on any HVAC system. The HVAC system discharge temperature, space temperature, fan differential pressure, and filter differential pressure shall be monitored by the BMS.
8. All facility fans shall be designed and installed for automatic start and stop operation from the BMS. Provide local hands-off-automatic switch pushbutton control and indication light at each fan installation.
9. The Developer shall be responsible for providing BMS/DDC system testing, checkout, installation of wire, conduit, sensors, relays, switches, etc.

## 5.10 Special HVAC Systems

A. Building Distribution Facility (BDF) and/or Telecommunication Rooms

1. Provide adequate cooling for lights and personnel and ¾ ton of cooling to offset heat generated by networking and other telecommunication equipment.
2. The cooling systems for the BDF room and telecommunications closets shall be stand alone units and shall be supplied from an emergency/standby generator, if emergency/standby power is available at the facility.
3. Provisions shall be made for the Building Management System (BMS) to monitor the temperature of the BDF room and telecomm rooms and provide alarm indication if temperature exceed allowable limits

END OF SECTION 5 HVAC

# SECTION 6

# PIPING

6.1 Project Specific Criteria

A. Piped services to all associated equipment include steam piping system, hot and cold potable water, compressed air, Nitrogen, $CO_2$, Natural Gas, tower cooling water and "RO type" purified water. Services shall be piped from the main utility sources located near to building site or from source equipment located on the facility site.

B. It is the intent that the "developer" provide the base building for the Thermal Conversion Line equipment and Melt Spun Precursor Line equipment (supplied by other independent equipment suppliers) and also provide the supporting mechanical piped services to this equipment as needed at various locations along the production line.

C. Piping headers for the Cooling Water Supply and Return will be installed along and adjacent to and parallel to both production lines located along the inside wall of each side of the building. In the same location there will be also piping headers for both production lines for Nitrogen, Compressed Air, $CO_2$, as needed. Steam, Vacuum and Natural Gas line headers will be located where specified in equipment specification ORNL-CFTC-2010CFC01.

D. Main utility source piped services to the production line equipment from the piping headers will have branch termination tie-in points that include sufficient isolation valves, throttling valves, quick-disconnects, etc. repeated at intervals along the associated production line equipment such that the independent equipment suppliers can provide their piped services from the equipment to tie-in termination points. In addition, flow meters, pressure and temperature gauges will be installed at selected locations to verify that piped systems performance is in compliance with equipment operating requirements. Piped services required between equipment will be the responsibility of the independent suppliers.

E. Steam Boiler and associated piping will be designed for saturated steam @ 15 psig or less with a steam delivery capacity of 360 lbm/hr. Steam Boiler will be capable of operating at hot standby while the semi-production line in not in operation. Backup fuel source not required. Fuel source (natural gas or other) may be based upon the utilities available at selected site. No standby electrical power required. Steam Boiler will be sized for 100% capacity, vertical tubeless boiler, with no condensate return. Boiler will be supplied with all the associated piping, pipe fittings, valves, tanks and specialties including chemical treatment equipment as required.

F. Domestic water will be provided with a water meter at the building service entrance. The water meter will be sized for the building's maximum design flow rate. The building's domestic water service will be isolated from the municipal water systems by a duplex reduced pressure backflow preventer located downstream of the water meter. Domestic water will be provided to all toilet room fixtures, electric water coolers/drinking fountains, sinks, emergency shower/eyewash units, and any other devices that require a domestic water supply. Hot water @ $120^0$ F will be provided to all fixtures and devices that require hot water. Domestic hot water will be produced by a simplex gas-fired storage-type water heater. Duplex alternating water softeners will be installed ahead of the water heaters. The emergency fixtures (showers and

eyewashes) will be supplied with tepid water. Tepid water ($72^0$ F to $90^0$ F) to emergency fixtures will be provided by a master thermostatic mixing valve with cold water bypass device.

G. Breathing Air bottle stations will be provided at the same locations for the emergency eyewash/ showers at a minimum of two locations per production line.

H. Purified Process / Make-up water will be provided for Building and semi-production line needs with a minimum delivery capacity of 2 gpm. This water system will be provided to produce and distribute water meeting the same type quality requirements as "RO Type" systems to mechanical systems such as steam boiler, cooling tower loops, etc. A reduced pressure backflow preventer will be supplied and installed protect the domestic water supply from the purified process water system and will be sized for 100% of the design load.

**Specification – "De-mineralized" Purified Process Water Requirements**

| Component | Range | Units |
|---|---|---|
| Conductivity | < 5.0 | Micro-mhos (S/cm) |
| pH | 5.0 – 8.0 | pH units |
| Silica (SiO2) | < 1.0 | ppm |
| Iron, Mn, Sulfate | < 0.01 | ppm |
| Total Chlorine ($Cl_2$) | < 0.02 | ppm |
| Hardness ($CaCO_3$) | < 1.0 | ppm |
| Dissolved Organics (C) | < 0.5 | ppm |
| Sodium | < 50 | μg/l |
| Biological Content | - | - |

**Specification – Cooling Tower Water Requirements**

**Case 1. Water-cooled shell with mild steel, plate coil, copper inserts and transformers.**

| Property | Range | Units |
|---|---|---|
| Total Suspended Solids (TSS) | < 10 | ppm |
| | < 0.05 | in |
| | < 1270 | micron |
| Hardness ($CaCO_3$) | < 100 | mg/l or ppm |
| Conductivity | < 300 | Micro-mhos (S/cm) |
| Total Dissolved Solids (TDS) | < 200 | ppm or mg/l |
| pH | 7.0 – 8.0 | pH units |
| Total Chlorides | < 200 | ppm or mg/l |
| Silica ($SiO_2$) | < 150 | ppm or mg/l |
| Ammonia ($NH_3$) | < 2.0 | ppm or mg/l |
| Phosphates | < 4.0 | ppm or mg/l |
| Fluoride | < 10 | ppm or mg/l |
| Iron, Mn, Sulfate | < 0.01 | ppm or mg/l |

I. Tower Water will be provided for Cooling Water for the Semi-Production Line. There will be an open loop tower water (TW) system with a decoupled associated closed loop Cooling Water (CW) system. Design requirements for the semi-production line are with cooling water maximum supply temperature @ 91$^{o}$ F and maximum demand of 150 gpm. The maximum return cooling will be designed @ 108$^{o}$ F. Two cooling towers are to be provided at 100% capacity each. Two CW pumps and two TW pumps will be provided at 100% capacity each. One Heat Exchanger to be provided at 100% capacity. Towers, CW pumps and TW pumps on standby power. Sump shall be protected against freezing during the cold weather.

J. Quench / Deluge water system for the semi-production line will be provided to discharge 1200 gallons in 10 minutes @100 psig.

K. A piped vacuum collection system will be provided to specific equipment located throughout the building to collect dust particles, etc. and sent to a central vacuum tank and/or bag.

L. Nitrogen gaseous header system will be provided along the length of both sides of the semi-production line walls to serve outlets and equipment as required by the Owner. Nitrogen service will be from a liquid nitrogen bulk tank (GFE). The Nitrogen system will be designed to provide 30 psig nitrogen at the most remote outlet or equipment connection. The estimated demand for Nitrogen gas for the semi-production line will be 200 cfm.

M. Compressed Air will be provided to equipment and for general use @ 100 psig and a dewpoint of 40$^{0}$ F. Compressed Air piping system will be sized based on minimum 1 scfm per outlet plus any specific flow requirements for individual pieces of equipment. Compressors will be supplied and controlled by pressure switches in receiver set to operate between 100 and 115 psig. Each compressor will be sized for 50% of the maximum total demand of 825 cfm. The compressors will be controlled on lead/lag/alternate basis.

N. Natural gas is anticipated to be piped to equipment (building heating, steam boiler, water heater, etc.) as required to meet building needs. Gas Building pressure will be determined based on total equipment needs. Natural gas will be extended to the building from the gas utility natural gas main in the street. It is anticipated that the gas meter will be located at grade at the service entrance to the building. The estimated peak natural gas demand for the semi-production line equipment part is 2200 cfh @ 8 psig. Additional natural gas demand for other building systems will be determined from the Design of the Building.

O. An open trench will be provided down the center of the production line floor large enough to hold the waste water fluid volume of 1500 gallons. Piped drains will direct this fluid from the open trench to the waste holding tank. Trench will be provided with a grated cover designed to handle forklift loads.

P. Waste systems to all laboratories will include sanitary drain and laboratory waste.

Q. Services shall be provided to each overhead service carrier, hood, and sink at a minimum. Where a service does not connect to a fixture, the pipe shall enter each area and terminate with an isolation valve and cap.

R. Provide header isolation valves for maintenance and leak repair. At a minimum, provide isolation valves at each floor and at each branch header connection. Where long runs exist on a single floor provide additional isolation valves and crossovers if necessary.

S. The Building Automation System, BAS, shall monitor the water and gas meter, pure water system, facility waste tank and other requirements of this section. Additional piping monitoring points will be determined at the 30% review. Additional requirements of the BAS are included in Section 5, HVAC.

## 6.2 Design Standards

A. Standards

1. ASME B31.3, Process Piping.
2. ASME Boiler and Pressure Vessel Code (BPVC) Sections I, II, IV, V, VI, VII, VIII, IX and X.
3. AWWA D100, Standard for Welded Steel Tanks for Water Storage.
4. NFPA Standards
   a. NFPA 22, Standard for Water Tanks for Private Fire Protection.
   b. NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.
   c. NFPA 51, Standard for the Design and Installation of Oxygen–Fuel Gas Systems for Welding, Cutting, and Allied Processes.
   d. NFPA 54, National Fuel Gas Code, ANSI Z223.1.
   e. List as determined by the Authority having Jurisdiction.
5. International Building Code, 2006

B. Additional Standards/Guides

1. Economic Insulation Thickness Guidelines for Piping and Equipment
2. Underwriter's Laboratories (UL)
3. Factory Mutual (FM)
4. ASHRAE 90.1, Energy Standard for Buildings except Low-Rise Residential Buildings.
5. ISEA Z358.1, Emergency Eyewash and Shower Equipment.
6. ASME B31.8, Gas Transmission and Distribution Piping Systems.
7. AWWA M41, Manual of Water Supply Practices, Ductile Iron Pipe and Fittings
8. ANSI A 13.1 Scheme for Identification of Piping Systems
9. Foundation for Cross-Connection Control and Hydraulic Research
10. System Description Document, Water Distribution System

## 6.3 General

A. Reliability- Systems for critical applications shall be designed with sufficient backup so that the failure of any one component does not preclude operation of the system.

B. Maintainability- Equipment arrangements shall allow for all maintenance access requirements, component removal space, lay down areas and any other clearances necessary for safe

operation, maintenance, replacement, and repair of all equipment. Maintainability designs shall minimize disruption of building functions.

C. Flexibility- the piping systems shall be sized to meet their intended load, plus 10% spare capacity unless otherwise specified.

D. Provide all utility connections and services required for a complete and operational building.

E. Capacities and sizes of pipes, pumps, and other equipment shall be determined by performing calculations based upon the requirements noted on Room Data Sheets and other building area requirements contained herein.

F. If new building or other permanent structures are to be built above existing underground mechanical utilities the underground utilities shall be relocated.

G. All materials/equipment shall bear the Underwriter's Laboratories (UL) label or be approved by Factory Mutual (FM) where UL labels or FM approval is available for the type of products specified.

H. Material or components containing asbestos, polychlorinated biphenyl (PCB), CFCs, lead, and carcinogens shall not be utilized. Space shall be free from hazardous materials according to applicable federal, state, and local environmental regulations.

I. Acrylonitrile butadiene styrene (ABS) plastic pipe shall not be utilized.

J. The Authority Having Jurisdiction (AHJ) is the Company and /or the Local and State Regulatory Agency.

K. Relief valves shall be easily removed from the piping systems by means of flanges, threaded couplings, or other method.

L. Tracer wire

1. Tracer wire shall be laid continuously along to top of all buried piping.
2. Attached the wire at five foot intervals to the pipeline with several wraps of tape.
3. Tracer wire shall run up and down exterior side of valve boxes, looped but not cut, into the valve box just below the cover.
4. Splices shall be avoided. Splices and wire ends shall be waterproofed.
5. Verify electrical continuity by applying an electrical current.
6. Wire Spec: 14 AWG conductor, solid white, TWH solid copper with plastic coat. Splice connectors: Burndy KS-90 16-10 wrapped with insulating mastic tape.
7. The ends of the tracer wire shall terminate inside a valve or junction box. A minimum of twelve inches of wire shall be located within the box.

M. Backflow Preventers

1. Backflow preventers shall be approved by the Foundation for Cross-Connection Control and Hydraulic Research and shall be warranted for one year after accepted by the Company.

N. Label all pipes in accordance with ANSI A 13.1.

O. Cooling Tower Fans and variable speed pumps shall be provided with Variable Speed Drives (VSDs) and premium efficiency motors.

P. Variable Speed Drives (VSDs) supplied shall be provided with harmonic filters.

6.4 Piping Systems

A. Steam

1. Steam piping systems are to meet the requirements of ASME B31.3 - Process Piping, 0-50 psig category D fluid service, 50-250 psig normal fluid service.
2. All piping subject to ASME code shall satisfy the requirements of the ASME Code.
3. All piping shall satisfy the requirements of ASME B31.3 Code for the working pressure and service temperature involved.
4. All valves, fittings, flanges, and unions shall be marked according to MSS SP-25 standards.
5. Heating Steam - Steam used for heating air or potable water
6. Process Steam - All other steam usage.
7. Provide expansion loops with welded fittings to compensate for expansion of steam lines. Do not use expansion joints.
8. Provide meter for building steam usage. Include a bypass around the meter with isolation valves.
9. At strategic points, provide double isolation valves for maintenance of the equipment without effecting the steam system operation in the rest of the building.
10. Test completed piping systems in accordance with the ASME B31.3 Code.

B. Water

1. Water Main
   a. The water main shall be designed, installed and tested to the more stringent requirements of the Division of Water Supply, Tennessee Department of Environment and Conservation, or Community Public Water Systems Design Criteria or NFPA-24, Private Fire Service Mains.
   b. Water Main is defined as potable water and firewater piping from the water treatment facility up to and including the building isolation valve.
   c. The ORNL water supply system is a combined potable water and fire service main.
   d. Water mains should maintain the following distances from building foundations: 8” diameter or less - ten feet clearance, greater than 8” diameter - twenty feet clearance.

e. Design for normal operating pressure range of 40 - 100 psi.
f. Test pressure 200 psi.
g. Design the water main to use a looped – grid type system providing two-way flow with sectional valving arranged to provide alternate water flow paths to any point in the system.
h. Design the water main to deliver peak potable flow of 2 ½ times the average daily demand plus any special demands, at a minimum residual pressure of 30 psi at ground elevation.
i. Pipe restraint systems shall be designed per AWWA M41, Manual of Water Supply Practices, Ductile Iron Pipe and Fittings. Restraint systems can consist of concrete thrust blocks, EBBA Megalugs, and/or US Pipe Field Lok gaskets. Pipe restraint locations and details shall be shown on the drawings.
j. The building water supply and fire protection system water supply shall have separate piping feeding the building.
k. The building water supply shall be isolatable without affecting the fire protection systems.

2. Building Water Supply
   a. Building water supply system shall be designed to the International Plumbing Code.
   b. Building water supply system is defined as potable water pipe including the necessary connecting pipes, fittings, control valves and all appurtenances in the structure downstream of the building isolation valve.
   c. Building water supply pressure shall not exceed 80 psi, IPC 604.8.
   d. Backflow Prevention
      1) Reduced pressure principle backflow preventers, RPPBP, 2 1/2 inch and larger shall be manufactured by Watts Regulator Company. Reduced pressure principle backflow preventers 2 inches and smaller shall be manufactured by Wilkins Water Control Products.
      2) Provide RPPBP at potable water supply to automatic fire sprinkler and stand pipe systems.
      3) Provide RPPBP at branch lines supplying process or other water systems.
      4) Provide RPPBP on building water supply.
      5) Provide a vacuum breaker at all laboratory sinks and hose connections.
   e. Potable water heating shall meet the requirements of ASHRAE 90.1.
   f. Provide ASME code stamped tanks for hot water generation. Provide ASME approved relief devices.
   g. Provide an industrial water meter which has a local display as well as an electronic output for BAS connection on the building water supply.
   h. Provide exterior hose bibs for watering landscaping.
   i. Fixtures
      1) Minimum fixture count shall be 1.5 times the IPC minimum based on allowable occupancy floor, unless otherwise approved by the company.
      2) Men's and women's facilities shall be available on each floor, unless otherwise approved by the company.
      3) Water closets shall be elongated bowl, vitreous china and wall hung.
      4) Water closet flush valves shall be low consumption with dual control handle.

5) Urinals shall be vitreous china, ultra low consumption, 1/8 gallon per flush, hardwired sensor system.
6) Lavatory
   a) Faucets shall hardwired sensor system with 0.5 gpm vandal resistant aerator and temperature mixing valve.
   b) Wall mounted lavatories shall be white vitreous china.
   c) Countertop sinks shall be integral with the countertop.
7) Shower systems shall be ADA compliant and low flow, with a single handle thermostatic/pressure balancing mixing unit.
8) Kitchen sink faucets shall be ADA compliant and low flow, with 1.5 gpm vandal resistant aerator. Sinks shall be 18 gauge Type 302 self-rimming stainless steel with 3 faucet holes.
9) Laboratory sinks and faucets shall be provided by the casework contractor. Laboratory faucets shall be goose neck type with integral vacuum breaker. If purified water is available a separate faucet shall be provided at the sink.
10) Mop sink faucets shall have integral vacuum breakers, hose threaded outlet, and a pail hook. Mop basins shall be 24” x 24” x 10” deep service basin of crushed stone, resins and reinforcing strands.
11) Mop sinks shall be floor mounted.
12) Water coolers shall be split level electric delivering 8 gpm of 50 degree F drinking water.

3. Fire Protection
   a. The riser supply main shall be provided with a supervised post indicator gate valve (PIV).
   b. Fire protection within the facility is covered in Section 7.0 Fire Protection.
4. Eye Wash and Safety Shower
   a. Emergency showers and eyewash stations shall meet ISEA Z358.1.
   b. Emergency showers and eyewash stations shall be provided with water from the building water supply system.
   c. Water supplied to the emergency shower and eyewash stations shall be maintained between 72 degrees F and 90 degrees F, unless otherwise specified.
   d. Valves capable of isolating the emergency showers and eyewash stations shall be tagged “Emergency shower and eyewash station isolation valve – DO NOT OPERATE without approval of the Facility Engineer”. Tags shall be permanently attached to the valve without interfering with the valve operation.
   e. Heavy gauge nylon wire tie or similar material shall be installed to prevent inadvertent operation of the isolation valves.
   f. Combined emergency shower and eyewash station or standalone emergency shower water shall drain into the waste tank.
   g. Standalone eyewashes may be located at sinks with sanitary or process drain connections.
   h. Eyewashes and safety showers shall be Bradley, Encon, Haws, or Speakman.
   i. Eyewashes shall be swing activated and mounted at lab sinks, Bradley Emergency Eyewash Swing Activated S19-270 or equal.
5. Process Water

a. Process water shall be provided locally from the potable water system through an approved RPPBP.

6. Purified Process Water

a. Make up water to the Purified Process water system shall be provided locally from the potable water system through an approved RPPBP.
b. The purified water system shall meet the requirements of the International Plumbing Code.
c. Purified water is defined as potable water treated by distillation, ion-exchange treatment, reverse osmosis, or other suitable process from outlet of generating equipment to point of use.
d. Provide a recirculation purified water system meeting the requirements of the National Committee for Clinical Laboratory Standards and the College of American Pathologists Type III Reagent Water.
e. The water quality shall be continuously monitored through the programmable logic controller and the BAS.
f. Pipe material shall be ASMT D4101, unpigmented Type I homopolymer polypropylene, Orion Whiteline Pipe or equal.

C. Raw Water

1. Design raw water systems to meet the requirements of ASME B31.3 - Process Piping, category D fluid service.

2. Raw water is defined as untreated, or partially treated, water.

D. Tower and Chilled Water Systems

1. Design tower and chilled water systems to meet the requirements of ASME B31.3 - Process Piping, category D fluid service.

2. Tower water and chilled water is defined as chemically treated water re-circulated through mechanical cooling equipment.

3. Chilled water and condenser water quality for the facility shall be considered commercial grade.

4. Include strainers at all chilled water coils that will filter 100 micron particles.

5. Dust particles, suspended or partially dissolved solids, etc. shall not be filtered and shall remain in the system.

6. Pipe hangers and supports shall not penetrate the insulation on chilled water lines.

7. Once through cooling systems are not allowed.

8. Specify that all chilled water systems conform to these performance requirements:

a. Chilled water closed loop systems: Conductivity 800-5000 mmhos, pH 8-9.5, Bioscan 40 Rlu, Nitrite 600-1200 ppm, Total hardness 70-100 ppm TDS.
b. Condenser water open loop systems: Conductivity 1100-1300mmhos, pH 8-9, Molybdenum Tracer (ppm as Mo) 0.8 to 1.2, Chlorine-Total ppm as Cl2 0.0 to 1.0, Bioscan 40 Rlu.

c. Corrosion rate coupons shall be provided as part of the water treatment system on both chill water and condenser water. Corrosion coupon rates will be maintained under 1.0 mils/year for mild steel and 0.5 mils/year for copper.

d. Corrosion inhibitor system shall GE Betz or approved equal.

9. Specify that the chilled water systems and tower/condenser water systems be cleaned prior to start-up per the following.

   a. Fill system with clean water and add cleaning chemicals to the system at a concentration of at least 1000 ppm. Use GE Betz FerroQuest 7101 or equal as specified by ORNL.

   b. Start pumps and begin circulation. Circulation rate should be at least design flow and preferably should result in a pipe velocity greater than 6 feet per second. Circulate for 1 hour, shut down, drain sediment from system low points, and clean all strainers.

   c. Start pumps again and circulate for 72 hours while monitoring for leaks and temperature rise. Circulation should be through the entire system including coils, etc. All control valves should be verified 100% open. The pH will rise during circulation as the cleaning chemical begins to perform. Adjust pH levels downward using GE Betz FerroQuest 7102 as necessary.

   d. While continuing to circulate, bleed water to sanitary sewer at no more than 5 GPM while simultaneously making up at equal flow rate. Continue until water is clear and will not foam when poured into a bucket. Do not stop pump circulation as suspended matter will settle and accumulate at system low points.

   e. Check the Ph of the system and adjust as necessary. Add the initial dose of water treatment chemicals as specified, and have the Local/State water treatment representative certify the initial condition of the circulated water.

   f. Vendor shall provide chemicals as specified for cleaning the system.

   g. Disposal of pipe cleaning chemicals and flushing water shall be the responsibility of the Subcontractor. However, an option to dispose of the pipe cleaning chemicals and flush water using the Local Sewage Treatment Plant (STP) provided that the flush water meets the waste acceptance criteria (WAC) for the Local STP. Flush water that exceeds the WAC may be allowed on a case by case basis provided a variance to the WAC is approved by the Local / State representative prior to discharge.

10. See Section 5 - HVAC for additional requirements.

E. Liquid Nitrogen

1. A nitrogen tank will be leased by the Company. The tank will provide both liquid and gaseous nitrogen as required.

2. Provide liquid nitrogen hard piped to laboratories per the room data sheets.

3. The contractor is responsible for design, procurement and installation of the nitrogen delivery systems from the leased tank and equipment.

F. Wastewater

1. General

a. Definitions

1) Wastewater drainage systems - floor drains, sanitary sewer, storm water management system, chemical drains and laboratory waste.

2) Sanitary Drainage System – All of the piping within a building that conveys sewage to the building sanitary drain.

3) Building Sanitary Drain – The lowest piping of a sanitary drainage system inside a building extending 30 inches beyond the wall of the building.

4) Building Sanitary Sewer – From the building sanitary drain to the Sanitary Sewer System.

5) Sanitary Sewer System – The common sanitary sewer conveying sanitary sewage to the City of Oak Ridge Sewage Treatment Plant or other municipality having sewage treatment facility.

6) Storm Drainage System - All of the piping within a building that conveys rainwater, condensate, cooling water or similar liquid wastes to the City Of Oak Ridge or other municipality having a Storm Sewer System or other point of disposal to the environment.

7) Municipality Storm Sewer System – The common storm sewer conveying rainwater, surface water, subsurface water and similar liquid wastes to the local city, town or county outfalls.

8) Laboratory Waste Water – a wastewater stream originating within laboratory areas which are routed to a waste holding tank.

9) Sanitary Waste Water – a wastewater stream meeting the criteria of Waste Acceptance Criteria for the associated Sewage Treatment Plant.

10) Other Waste Water – a wastewater stream not meeting :

- Wastewater Discharge Criteria for Process Wastewaters, or
- Waste Acceptance Criteria for the associated Sewage Treatment Plant
- Or the requirements of the storm drainage system.

b. Wastewater systems shall be incompliance with the following criteria:

1) Storm Water Pollution Prevention Plan

2) Waste Acceptance Criteria for the Sewage Treatment Plant

3) Wastewater Discharge Criteria for Process Wastewaters associated with the City of Oak Ridge and Local / State Regulations.

4) Waste Acceptance Criteria for Liquid Waste Systems associated with the City of Oak Ridge and Local / State Regulations.

c. Design wastewater collection systems for gravity flow unless such systems are not economically feasible.

2. Sanitary Drainage

a. Design sanitary drainage systems to meet the requirements of International Plumbing Code.

b. Kitchen and breakroom design shall consider grease traps to meet the requirements of International Plumbing Code.

c. See Section 2, Civil, for Building Sanitary Sewer.

3. Storm Drainage

a. Design storm drainage system to meet the requirements of International Plumbing Code.
b. See Section 2, Civil, for Storm Sewer System criteria.
c. The storm drainage system shall not be used for discharging of laboratory waste or sanitary drainage.
d. The storm drainage system shall not be used for any constitutes restricted for such as defined in the regulations for the City of Oak Ridge and/or other Local / State Regulations.

4. Laboratory Waste

a. Design laboratory waste drain system to meet the requirements of ASME B31.3 - Process Piping, category D fluid service.
b. Laboratory waste piping material shall be:
   1) PE Drainage Pipe and Fittings: Made of ASTM D 4976, PE resin, Schedule 40, socket-fusion;
   2) PP Drainage Pipe and Fittings: ASTM F 1412, fusion joints;
   3) PVC Drainage Pipe and Fittings: ASTM D 2665;
   4) PVDF Drainage Pipe and Fittings: ASTM F 1673, Schedule 40, fusion joints;
   5) Or as determined by evaluating the intended use.
c. Laboratory waste shall be piped and collected in a laboratory waste tank within the facility.
   1) Design for gravity flow unless such systems are not economically feasible.
   2) Provide a no smaller than 2000 gallon liquid waste tank. The tank shall be single lined HDPE or ASTM D 4101, PP and shall have a secondary containment system, ie dike or secondary tank/basin fabricated from similar material. If liquid can't be seen in the tank, provide a sight glass or level instrument with gage and local display.
   3) Provide a leak-detection system capable of detecting and annunciating fluid leaks within the secondary containment, wiring, cable sensors, probes if required, and piping.
   4) All instruments shall be tied into the BAS system to provide continuous level monitoring, pump operational status (if applicable), high and high/high level alarm for tank contents, leak detection alarm and solenoid valve on the discharge (if applicable).
   5) Include capability via nozzle, valve, dip tube and proper venting on the tank, etc. to pump to a tanker truck.
   6) Tank shall be located at the lowest elevation possible and wall penetrations or other provision shall be made to allow access to the tank by a tanker truck so contents can be pumped out.
   7) The discharge piping system shall have a positive shut-off method.

5. Floor Drains

a. Design floor drains to meet the requirements of International Plumbing Code.
b. Do not provide floor drains for safety showers unless routed to waste tank.
c. Do not provide floor drains in labs unless routed to waste tank.
d. Where there is the possibility of the loss of the seal in floor/funnel drain traps, provide a trap primer valve and floor/funnel drain with a trap primer valve discharge connection.

e. Do not route floor drains to the storm sewer.
f. Certain floor drains may go to sanitary sewer if approved for use by City of Oak Ridge and /or Local / State Regulatory Agency unless are located in rooms where fuels, chemicals or other similar hazardous materials exist.
g. Where fuels, chemicals, and other hazardous materials may be found route floor drains to the waste tank provide no floor drains or provide raised drains to sanitary sewer.
h. Minimize the number of floor drains in mechanical rooms and central energy plants to prevent possible contamination (oil, etc.) transfer to the sanitary sewer system.
i. Floor drains located in restrooms shall be placed out of the walking areas, i.e. between the stalls or under the lavatories.

6. Control / Computer Room Raised Floors
   a. Provide indirect waste lines for all floor drains from under raised computer room floors (12" and deeper) and route to a sump, 100 gallon in size minimum.
   b. The sump shall be easily accessible and provided with a removable cover.
   c. Provide a back-water valve in the sanitary drain pipe and locate it in the sump so it can be easily replaced. The invert of the back-water valve shall be 12" minimum above the bottom of the sump for heavy solids accumulation.
   d. The sump shall not be located in a computer room and the sump size shall facilitate back-water valve replacement.
7. Elevator Pit
   a. Elevator sump pump, where provided, shall discharge to the sanitary drainage system.
   b. Elevator sump pump shall have an oil monitoring system that prevents the pump from operating when hydraulic oil is present and sends an alarm to the BAS.
8. Other waste
   a. Other waste shall be collected at the point of discharge in carboys or other tanks. The waste shall be pretreated prior to discharge or collected for offsite treatment by the waste originator.
9. Handling of Water and Waste Water at the Facility unless otherwise noted in Project Specific Criteria.
   a. Types of waste water piped to the Sanitary Drainage System:
      1) Janitor mop sinks.
      2) Toilets, urinals, lavatories, showers, hand sinks, water fountains, break room sinks, ice makers, etc
      3) Floor drains in restrooms.
      4) Floor drains in mechanical rooms and central energy plants.
      5) Mechanical room utility sink.
      6) Hand sinks in labs.
      7) Elevator sump pump.
      8) Sump discharge from control / computer room raised floor
   b. Types of waste water piped to the Storm Drainage System:
      1) Roof drains.
      2) AHU condensate. See Wastewater Sustainability section.
      3) Humidifier water blow-down

4) Condensate from large oil-less air compressors.
5) Condenser/tower water blow-down.
6) Condenser/tower water over-flow.
7) Neutralized condensate from condensing boiler stacks.

c. Types of waste water piped to the Sanitary Drainage System or Storm Drainage System:
1) Small point-of-use air compressor condensate discharge after going thru an oil/water separator.
2) Condenser water relief.
3) Evaporator make-up water relief and air separator drain.
4) Boiler water relief and drain.
5) Heating make up water relief and air separator drain.
6) Water heater relief.
7) Back flow preventer relief.

d. Types of waste water piped to Facility Waste Tank,
1) Lab sinks.
2) Fume hood cup sinks.
3) Shower / Eye washes.
4) Fluid in open trench from Quench Water, etc.

G. Compressed Air

1. Design compressed air systems made from steel or copper tubing systems to meet the requirements of ASME B31.3- Process Piping, category D fluid service.

2. Plant air is defined as compressed air, not oil free, at 100 psig pressure and dried to a dew point of -50°F to -70°F.

3. Instrument air is defined as compressed air that is oil free and dried to a specified dew point.

4. Maximum pressure at air hose outlets is 15 psi.

5. Provide laboratory compressed air that is oil free and dried to -40F dew point.

6. Provide 100 psi compressed air for building requirements and instrument air to all laboratories.

7. Compressed air may be provided by a dedicated 100% redundant oil-free compressor(s), receiver(s), dryer(s) and filter(s).

8. Provide flow instrumentation with electronic output for connection to BAS system

H. Compressed Gases

1. General

a. Design inert gas system piping to meet the requirements of ASME B31.3- Process Piping, category D fluid service.
b. Design flammable gas system piping to meet the requirements of ASME B31.3 - Process Piping, normal fluid service and the applicable NFPA code, unless otherwise indicated.

c. Compressed gas piping systems are from the outlet of the generating equipment, bottle station manifold, or storage facility to point of use.
d. Provide gas cylinder storage and unloading space at the loading dock.
e. Inert gases include nitrogen, argon, and helium.
f. Flammable gases include acetylene, hydrogen, oxygen, natural gas, propane and annealing gas.

2. Propane
   a. Design propane to meet the requirements of International Gas Code and the applicable NFPA code.

3. Natural Gas
   a. The natural gas distribution main shall be designed, installed and tested in accordance with ASME B31.8 - Gas Transmission and Distribution Piping Systems.
   b. Natural gas service lines shall be designed, installed and tested to the more stringent requirements of NFPA-54, National Fuel Gas Code, and the International Gas Code.
   c. Natural Gas Distribution Main is defined as the natural gas distribution piping from the Local Utility to the service regulators.
   d. Natural Gas Service Line is defined as the natural gas pipe downstream of the service regulator.
   e. An industrial gas meter with local display and electronic output for connection to BAS shall be provided on the natural gas service line.

4. Nitrogen
   a. A nitrogen tank will be leased by the company. The tank will provide both liquid and gaseous nitrogen.
   b. Gaseous nitrogen shall be provided to connect to equipment as specified on the room data sheets at the 30% design review.
   c. The contractor is responsible for design, procurement and installation of the nitrogen delivery systems from the leased tank and equipment.

5. $CO_2$
   a. A $CO_2$ tank will be leased by the company.
   b. Gaseous $CO_2$ shall be provided to connect to equipment as specified on the room data sheets at the 30% design review.
   c. The contractor is responsible for design, procurement and installation of the $CO_2$ delivery systems from the leased tank and equipment.

I. Refrigerants

1. Piping systems for refrigerants is covered under Section 5, HVAC.

## 6.5 Tanks

A. Vented steel water tanks, stand pipes, and reservoirs shall comply with NFPA 22 and AWWA D-100.

B. Pressurized and/or heated tanks and vessels shall be designed, fabricated, inspected, and stamped in accordance with the requirements of ASME Boiler and Pressure Code, Section VIII.

C. ASME Pressure Vessels shall be inspected after installation. Inspection shall be scheduled prior to placing the vessel in service. Inspections will be performed by the Authority Having Jurisdiction which is the Company if the site is located on DOE property and otherwise is the Local / State Regulatory Agency.

6.6 Steam Boilers

A. Power boilers and high pressure, high temperature water boilers shall be designed, fabricated, inspected, and stamped in accordance with the requirements of ASME Boiler and Pressure Code, Section I in which steam is generated greater than 15 psig or high temperature boilers with pressures greater than 160 psig and/or temperatures greater than $250^0$ F. For Water Boilers operating at 15 psig or less the rules of ASME Code, Section IV applies.

B. ASME Pressure Vessels shall be inspected after installation. Inspection shall be scheduled prior to placing the vessel in service. Inspections will be performed by the Authority Having Jurisdiction which is the Company if the site is located on DOE property and otherwise is the Local / State Regulatory Agency.

6.7 Insulation

A. Insulation for piping systems and auxiliary components and equipment shall minimize energy loss, prevent condensation, protect from freezing and provide safe surface temperatures. The Economic Insulation Thickness Guidelines for Piping and Equipment prepared by the North American Insulation Manufacturers Association (NAIMA) shall be the basis for determining insulation thickness.

B. Pipe hangers and supports shall not penetrate the insulation on chilled water lines.

6.8 Supports/Hangers

A. Piping systems, components and equipment Supports / Hangers shall be designed and anchored in accordance with Section 3 - Structural.

B. Support spacing shall not exceed spans given per ASME B31.1 Code, section 121, table 121.5 for metallic pipe and ASME B31.3 Code for non-metallic piping.

C. Locate, detail, and number and tag all anchors, hangers, and supports for piping larger than 2 inches in diameter. Provide an isometric drawing showing as-built information identifying the same with the pipe configuration and pipe support locations.

D. Pipe hangers and supports shall not penetrate the insulation on chilled water lines.

6.9 Corrosion Protection

A. Protect piping against corrosion either by natural resistance of the material or by other protective measures, see Section 8 - Electrical for cathodic protection.

6.10 Drawing Information

A. Flow diagrams shall show system designations, line numbers, line sizes, equipment, valves and piping specification number. System designations shall be defined on the drawings and may be the A-E's standard designations.

B. Valves shall be identified by a standard valve number and unique valve identifier. Valve identification numbers (VIN) will be provided by the Developer.

C. Include the following tables on the piping drawings:

1. Table listing each service, designation, and specification subsection
2. Table listing each service design pressure, design temperature, test pressure, test type, and test media.
3. Valve table that includes the VIN, standard valve number, type, and (if applicable) instrument number.
4. Table listing pressure reducing and relieving devices that shows type, size, pressure setting and capacity.
5. Table listing insulation type and thickness.
6. Table listing backflow protection devices include location and backflow preventer device type.

END OF SECTION 6 PIPING

# SECTION 7

# FIRE PROTECTION

7.1 Project Specific Criteria

A. The facility shall be classified by the International Building Code (IBC) 2006 as a High Hazard Group H-3 per Table 307.1(1) for maximum allowable quantities per control area.

B. The minimum type of construction shall be Type IIIB per IBC Table 502 and required by the DOE 1066-99.

C. The facility shall be protected throughout with an automatic wet pipe sprinkler as described in Section 7.4 of this document. The occupancy hazard classification as defined by NFPA 13 is Ordinary Hazard Group 2 except for where raw fiber is produced, stored or used. Areas for production, storage or for use of raw fiber (creel) shall be protected with Extra Hazard, Group 2 sprinkler protection. EH2 shall be provided for but not limited to the following areas: Polymer compounding, pelletizing, and spinning area both above and below the spinning equipment platform; fiber storage room, under mezzanine where fiber is stored/used, and high bay above the mezzanine where combustible fiber is stored/used, and the area of the high bay between the storage/use areas and the entrance into the first oven. The combustible fiber shall be protected as a Group A plastic.

D. A fully addressable fire alarm signaling system shall be provided and installed as described in Section 7.4 of this document.

E. Roof system shall be a Factory Mutual Global Class 1 approved type and shall meet UL Class A fire exposure requirements.

F. Internally illuminated exit identification and directional signs shall use LED type illumination. Emergency light units and exit signs with internal back up power shall be a self-diagnostic type, if provided.

G. If provided, emergency power provisions shall comply with the requirements of the International Codes Council® (I-Codes) package, including NFPA 110, Standard for Emergency and Standby Power Systems and other references.

H. The building water supply shall be provided with sectional valves within 10 feet on each side of the tie-in location. Sectional valves shall be designed and installed to provide alternate flow paths to the incoming main with the loss of a portion of the City of Oak Ridge water main. Fire mains shall be at least 8 inch diameter, except those supplying a single fire hydrant or extensions of existing smaller mains. Water supply mains feeding a single sprinkler system shall be at least 6 inch diameter. Water supply mains shall be sized to supply the largest expected fire suppression flow demand plus the largest potable water domestic demand. Residual sprinkler system pressure requirements shall be included in the design. The design and installation of all combined potable and fire water supply system components shall be in

accordance with the requirements of the applicable I-Codes and references, including NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances. No domestic water shall be connected to the water main downstream of the Post Indicating Valve for the sprinkler system.

I. Portable fire extinguishers shall be located for placement by the designer in accordance with the I-codes package, including NFPA 10, Portable Fire Extinguishers. The designer shall determine if any facility hazards require specific types or quantities of portable fire extinguishers. The hazard(s) to be protected, type(s), locations, and quantity of portable extinguishers by type shall be indicated on the documentation described in this section. The building owner shall provide the required number of portable fire extinguishers. Recessed wall cabinets may be installed where appropriate to accommodate portable fire extinguishers for areas with Ordinary hazards. Placards shall be mounted above each unit for identification.

J. Direct access to fire department connection(s) and the fire alarm system control panel(s) shall be provided. Fire department access shall be provided in accordance with the I-Codes package, and as accepted by the AHJ. Keyed access shall be provided to all areas and spaces of the facility for emergency response forces.

K. Where provided, all ventilation and duct smoke detection components and functions shall be in accordance with the applicable I-Codes package, including NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilation Systems. In-duct-type smoke detectors shall be photoelectric-type. The design and installation of the smoke detectors shall be in accordance with the current edition of NFPA 72, National Fire Alarm Code and shall be connected to the building fire alarm signaling system.

L. The building's electrical system shall be designed and installed in accordance with the applicable I-Codes package, including the current edition of NFPA 70, the National Electrical Code. Interior electrical transformers shall be dry-type. Exterior transformers shall be Factory Mutual approved or otherwise properly protected and/or located.

M. Lightning protection systems shall be considered for all buildings. A risk assessment using the guide in Appendix H of NFPA 780, Standard for the Installation of Lightning Protection Systems shall be prepared to determine the risk of loss due to lightning. When lightning protection is recommended, the lightning protection system shall comply with NFPA 780.

N. Seismic bracing for sprinklers shall be provided. Installation of seismic bracing shall be in accordance with NFPA 13.

O. When provided and as required by Section 712.4.1.1.2 of the IBC, through penetrations and membrane penetrations shall be protected by an approved through-penetration firestop system installed and tested in accordance with ASTM E814 or UL 1479. Drywall compound shall not be accepted for sealing either through-penetrations or membrane penetrations in a fire resistance rated barrier. All firestop caulk and putty shall be the color red with the exception that elastomeric sprays and sealants for fire rated construction joints may be the color white. Firestop sealant requirements should be written for compliance with the product requirements of Specified Technologies Inc. (STI) and/or equal. The General Contractor shall determine the

manufactures brand of firestop materials to be used on the project, and all project subcontractors shall be required to use the manufacture's products selected by the general contractor. In all applicable shop drawing submittals, the contractor shall be required to submit on the drawings an appropriate Firestop UL System Assembly File Number and Detail for each type of fire barrier penetration to be made by their system and/or equipment. Installation of firestop sealants shall be completed as soon as possible by the responsible contractor before access to penetrations becomes obstructed by other systems and equipment that is installed by other contractors.

P. The sprinkler system riser shall be located in a dedicated room that is accessed from the exterior of the building. The room may be provided with a structural steel, gridded ceiling to allow heat into the riser room from the building. A low temperature alarm shall be located within the riser room and connected to the fire alarm system. Access to the riser room shall be acceptable to the AHJ. The riser room shall be sufficiently large enough for the installation of a back flow preventer and the necessary piping for the forward flow testing equipment.

Q. Cooling towers, where provided, shall be in accordance with the I-Codes package, including NFPA 214 Standard on Water-Cooling Towers. Construction shall be of noncombustible materials, or be FM-Approved cooling towers. Noncombustible is defined as materials that pass ASTM E-136, Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 C.

R. Reserved.

S. A Preliminary Fire Hazards Analysis (FHA) will be prepared for this facility. Specific safety features and design elements are identified in the FHA must be incorporated into the design solution.

T. Special precautions will be needed for the design of the sprinkler system. Areas used for the bulk storage of raw fiber are required to be provided with Extra Hazard, Group 2 protection. The storage area shall be noted on the fire protection shop drawings and also on the code footprint drawings.

7.2 Codes, Standards, and Specifications

A. City of Oak Ridge, TN.
   1. The design and construction shall comply with the following I-Codes requirements:
      a. International Building Code, (IBC, 2006 (as amended by the City of Oak Ridge)
      b. International Fire Code, (IFC), 2006 (as amended by the City of Oak Ridge)
      c. International Fuel Gas Code, (IFGC), 2006
      d. International Mechanical Code, (IMC), 2006
      e. International Plumbing Code, (IPC), 2006
   2. The design and construction shall also comply with the following National Fire Protection Association, (NFPA) requirements:
      a. NFPA Standards (except NFPA 5000), as applicable as determined by the Authority Having Jurisdiction (AHJ)
      b. NFPA 1, *Uniform Fire Code*®

c. NFPA 13, *Automatic Sprinkler Systems*
d. NFPA 70, *The National Electrical Code®*
e. NFPA 72, *Fire Alarm Code*
f. NFPA 101®, *Life Safety Code®*

B. Other

1. These requirements shall be considered minimum requirements for the facility design solution. Where conflicts between the two sets of requirements arise, the most stringent requirements shall be used as determined by the AHJ and documented in the design documentation.
2. Modifications of the intent of the I-Codes and NFPA requirements shall be presented to the AHJ for acceptance before execution, with adequate time allowed for review and consideration. Documentation of the modification(s) shall be included in the required documentation.
3. Technical standards, codes, and guidance required for the design solution development, which are in addition to the I-Codes and references, shall be identified and submitted to the AHJ for acceptance. Acceptance shall be documented before being implemented in the design.
4. Design solution requirements shall be based on the edition of the codes and standards in effect at the time the facility design is accepted. These codes and standards, and the edition used, shall be documented and shall establish the "Codes of Record."
5. As-built drawings and documentation, consisting of the code footprint and drawings and documents required by the codes and standards for fire protection systems, shall be provided to the AHJ before facility acceptance.
6. All design records shall be submitted to Company for review and concurrence to ensure that the facility is in compliance with Department of Energy fire protection requirements. Final drawings, code footprint documents, etc. shall be submitted to Company.

C. General

1. Company will provide in conjunction with the City of Oak Ridge, code compliance review, interpretation, application, and oversight services pertaining specifically to the non-structural aspects of the I-Codes requirements and the additional fire protection requirements in this document. The City of Oak Ridge will provide final approval of all submitted documents. For general reference, the I-Codes non-structural code sections and references include (but may not be limited to) the following:
   a. International Building Code: Entire document and referenced codes and standards.
   b. International Fire Code: Entire document and referenced codes and standards.
   c. International Mechanical Code: Entire document and referenced codes and standards.
   d. International Gas Code: Entire document and referenced codes and standards.
   e. National Fire Protection Association (NFPA) Codes and Standards.
   f. National standards and guidance documents from ASME, ANSI, ASHRAE, UL, Factory Mutual Global, AWWA, and others as determined by the designer and accepted by the Company.

7.3 Authority Having Jurisdiction (Code Compliance Review and Acceptance Authority)

A. Pertaining to subjects included in this section, the final representative for code compliance design review and acceptance, as generally specified in the International Building Code Chapter 1, is the City of Oak Ridge.

7.4 Fire Protection System Design and Installation Requirements

A. Qualifications

1. All fire protection design packages, including fire suppression, fire detection and fire alarm drawings, specifications, and calculations, shall be prepared by a Tennessee licensed engineer in accordance with applicable state law, rules, regulations, and the guidance and policies promulgated by the Tennessee Board of Architectural and Engineering Examiners. Design and installation activities of all fire protection systems shall comply with the State of Tennessee requirements for such systems, including contractor licensing and documentation. Designs shall be submitted to the Company for review and to the City of Oak Ridge for review and acceptance. Fire Protection System design submittals shall comply with the applicable I-Codes and references, NFPA 1, Fire Prevention Code and references, the submittal requirements of this section, and the requirements of the applicable codes and/or standards for the particular type of system.

2. Fire Sprinkler Systems
   a. All sprinkler system designs and submittals shall be consistent with the State of Tennessee "Standard of Care." The design shall be sealed, signed and dated by a registered engineer (licensed in the State of Tennessee) competent in the design of sprinkler systems as required by paragraph 7.4.A.1 above. Sprinkler shop drawings submitted by a licensed sprinkler system contractor shall be coordinated with and approved by the registered engineer.
   b. All fire sprinkler system installations shall be performed by a fire protection sprinkler system contractor licensed as required by item 7.4.A.1 above. All sprinkler systems shall be installed under the supervision of a competent registered engineer or NICET Level III engineering technician.

3. Fire Detection and Alarm Systems
   a. All fire alarm system designs shall be sealed, signed, and dated by a registered engineer competent in the design of alarm systems as required by item 7.4.A.1 above.
   b. All system installations shall be performed by a fire protection alarm system contractor licensed as required by item 7.4.A.1 above. All fire detection and alarm systems shall be installed under the supervision of a competent registered engineer or NICET Level II engineering technician.

B. The design of fire sprinkler systems shall comply with NFPA 13, Automatic Sprinkler Systems and the following additional requirements.

1. The automatic sprinkler system shall be a wet pipe system.
2. The system shall be hydraulically designed using no less than the Ordinary Hazard, Group 2 except Extra Hazard, Group 2 Area/Density curve will be provided for storage/use areas of raw fiber (creel). Adequate allowances shall be provided for the installation of required backflow prevention devices.

3. Seismic bracing for sprinklers shall be provided.
4. Extra Hazard Group 2 sprinkler protection is required for all areas were raw fiber (creel) is stored or used. This area shall be extended to where the fibers enter the first oven. The EH2 sprinkler protection shall provided protection for a Group A plastic.
5. An alarm check valve shall be provided and equipped with an approved pressure switch or flow switch and tamper switch for valve indicating and supervising the valve position.
6. Sprinkler protection shall be installed in all areas and spaces per the applicable codes/standards and as specified and accepted by the Company.
7. Sprinklers shall be ordinary response type, contain no O-rings in the operating design, have a current date (within one year), and use a frangible bulb operating element. Semi-recessed sprinkler heads shall be provided in areas with suspended ceiling.
8. Pipe shall be at least Schedule 40 steel as specified in the applicable codes and standards.
9. Non-metallic pipe and fittings are not to be used unless specifically authorized by the AHJ.
10. The riser supply main shall be provided with a supervised post indicator gate valve (PIV) downstream of the connection for potable waters if provided from this main. The location of the PIV shall be in compliance with the I-Codes.
11. The indoor sprinkler system riser shall be provided with an outside stem and yoke (OS&Y) gate valve.
12. The sprinkler system design and installation shall coordinate, as needed, the electronic supervision of the system supply PIV, OS&Y control valve at the riser, and alarm bypass (test) valve.
13. The sprinkler system installer shall coordinate as needed to ensure efficient and effective tie-ins of sprinkler system fire alarm connections and water supply connections.
14. Sprinkler water supply line shall be no smaller than 6 inch diameter pipe, and no smaller than the system riser size.
15. Locate sprinkler system riser in a dedicated room at an exterior wall with access from the building exterior. Personnel access from the riser room to any other portion of the building is prohibited. The riser room size and layout shall accommodate installation of the required backflow prevention device(s) and associated isolation valves. Valving and associated piping shall be provided as necessary to facilitate the forward flow test requirements of NFPA 25 *Standard for Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems* without physical modification of the system other than opening or closing of installed valves.
16. The fire department connection shall be located for best emergency access as accepted by the AHJ.
17. Acceptance testing shall be witnessed by a representative of ORNL and as required by the AHJ, and shall be in accordance with the applicable codes and standards for the type of system. Required documentation shall include marked-up drawings at acceptance. Accurate as-built drawings shall be completed and submitted hard copy and electronically to the ORNL and the City of Oak Ridge upon completion of the job.
18. Pipe and components shall be labeled in accordance with applicable codes and standards. Exposed sprinkler pipe shall be primed and painted red (chip 21105).
19. There will be a minimum of three mezzanines within the building. The sizes of the mezzanines are: two at 500 sq ft. and one at 1000 sq ft. The exact location has not been determined. The sprinkler contractor shall interface and coordinate with ORNL to determine the placement of said mezzanines.

20. The selection of the sprinkler heads in the high bay area shall ensure that the selected sprinkler heads are listed for the designed ceiling height which is approximately 35 feet. Based on the selection of a Underwriters Laboratory Listed/Factory Mutual Approved sprinkler head, the operating specifications may be modified.
21. The temperature rating of the sprinkler heads shall be specifically addressed by the sprinkler contractor. It is likely that the ceiling temperature will be in excess of 100 degrees Fahrenheit on a routine basis.
22. The sprinkler contractor shall determine whether adequate water supply is available to supply the required design of the sprinkler system. If adequate water supply is not available for the sprinkler system, fire pumps shall be installed in accordance with NFPA 20, *Installation of Stationary Pumps*.
23. If fire pumps are provided, they shall be designed, installed, and tested in accordance with the requirements of NFPA 20.

C. The design of the fire detection and alarm system shall comply with NFPA 72, National Fire Alarm Code and the following additional requirements:
1. A fully addressable fire alarm control panel shall be provided for a building. The fire alarm control panel shall be compatible with the Central Monitoring Station and as approved by the AHJ. The fire alarm system shall be installed in a location accepted by the AHJ. Design and installation shall be in accordance with the applicable codes and standards, and the additional requirements in the Electrical section and this section.
   a. The primary purposes of the system shall be to provide local alarm notification, both audible and visual to facility occupants and transmit system signals to a Central Station Monitoring Facility.
   b. The fire alarm panel shall have printer device connection capability for report generation. The panel shall be provided with switches capable of disabling functions and shutdowns as determined during system design.
   c. All fire alarm equipment and components shall be UL Listed..
   d. The system shall transmit alarms, common trouble, and supervisory signals to the Central Monitoring Station.
   e. The fire alarm system shall be provided with battery backup power in accordance with NFPA 72.
   f. The transmission equipment shall transmit compatible system signals to the Central Station Monitoring Facility. Appropriate and acceptable reception of signals at the central receiving system shall be considered an integral function of the building fire alarm signaling system.
2. Manual fire alarm pull stations shall be provided adjacent to each designated required exit. The manual pulls shall be identified with signs mounted above the device.
3. Multi-sensor detector with base, photoelectric, ionization and heat detecting will be used, if provided. Detector plugs into separate base. Alarm LED on unit. UL listed for use with control equipment provided. Duct smoke detectors shall be provided as required by applicable codes.
4. The fire alarm system installer shall coordinate as needed to ensure efficient and effective tie-ins of sprinkler system fire alarm and supervisory connections.
5. All fire alarm wiring shall be run in dedicated, metallic raceways; no other wiring shall be allowed in the fire alarm raceways, enclosures, or junction boxes (except interfaces to devices and circuits controlled by the fire alarm system). Conductors supplying ac power

to the fire alarm system shall not be installed in the same raceways, enclosures, or junction boxes as fire alarm signal circuits. All fire alarm junction box covers shall be red in color for ease of identification.

6. Where a fire alarm system must interface with other systems, such as motor control or scram circuits, 24 V dc interface relays shall be provided in a separate enclosure to isolate the fire alarm system from the devices being controlled. The interface relays' contact ratings and configurations shall be specified as required for the application.
7. Where a fire alarm system interfaces with other systems for the purpose of fire control, such as an air conditioner or electrical power shutdown circuit, a means shall be provided to test the fire alarm system without affecting the other systems. This is usually accomplished by installing one or more supervised key switches in lockable enclosures. The method used shall have the approval of the AHJ
8. Interface equipment (modules, tamper switches, flow and/or pressure switches, etc.) shall be indicated on design drawings and provided as necessary to monitor components associated with the sprinkler system. In addition, duct smoke detectors, monitor modules, control modules, shall be provided as required by code to interface and manipulate the air handling equipment.
9. Reserved.
10. Reserved.
11. Acceptance testing shall be witnessed by a representative of the Company and as required by the AHJ, and shall be in accordance with the applicable codes and standards for the type of system. Required documentation shall include marked-up drawings at acceptance. Complete as-built drawings and CAD files shall be completed and submitted to the Company and City of Oak Ridge upon completion of the job.

## 7.5 Calculations

A. Hydraulically designed sprinkler calculations shall be provided in accordance with NFPA 13. The available water supply will be based on actual flow test data. Flow testing data will be provided when the location of the new facility has been selected. For design purposes, the static and residual pressures shall be reduced by a minimum of 10% to provide a margin of safety. This safety margin shall account for potential degradation of the underground water distribution system over the life of the facility.

B. Fire detection and alarm system power supply calculations for both primary and secondary (battery) shall be provided in accordance with NFPA 72.

## 7.6 Documentation

A. Fire protection systems design, calculations, acceptance testing, drawings and other as-built documentation shall be in accordance with the applicable I-Codes and references, the submittal requirements of this section, the requirements of the applicable codes and/or standards for the particular type of system, and State of Tennessee requirements for such systems. The following specific documentation is required as a minimum.

1. Fire sprinkler submittals shall include:
   a. Calculations, drawings, and equipment data as required by NFPA 13.
   b. Sprinkler layout and piping arrangement.

c. Sprinkler riser details including water supply tie-in.
d. Elevation views as necessary for clarity.

2. Fire detection and alarm submittals shall include:
   a. Calculations, drawings, and equipment data as required by NFPA 72.
   b. Device and circuit layout including device logical address in coordination with the riser and input/output matrices.
   c. Riser drawings.
   d. Input/output matrices.
   e. Fire alarm control panel detail drawings.
   f. Fire alarm interface details.

B. The "non-structural" aspects of facility fire protection, occupant safety, and code implementation and compliance shall be documented for design review, for documentation of changes, and for as-built documentation as described below:
   1. Single "code footprint" sheet for each floor.
   2. Graphic, contextual, schematic floor plan showing only the code compliance aspects of the design, containing the information described in this section.

C. Minimum requirements for the "code footprint."
   1. Schematic floor plan shall include:
      a. Graphic bar scale.
      b. North indicator.
      c. Complete floor plan.
      d. All permanent partitions taller than 6-ft.
      e. Each room and space clearly labeled with plain text, key notes, or legend.
      f. Occupant load for assembly areas and total for each floor.
      g. Stair and shaft enclosures with identification of ratings and opening protectives.
      h. Rated corridors with identification of ratings and opening protectives.
      i. Occupancy and area separations.
      j. Horizontal exit arrangements, exit passageways, and smoke compartments.
      k. Designated required exits and their capacity.
      l. Fire department connections and access to facility.
      m. Access to property and buildings.
      n. Power and fuels shut-off locations.
      o. Small scale site plan.
      p. Distances to exposures and "property" lines.
      q. Grade elevation at each building corner.
      r. Any special hazards or conditions.
      s. Location of any planned future additions.
   2. Narrative information on the code footprint shall include:
      a. Project purpose (new construction, addition, etc).
      b. Codes of record, including edition.
      c. Other significant requirements, including source.
      d. Building location.
      e. Facility name and owner.
      f. Date developed, and space for revision dates.
      g. Designer's information (name, address).

h. Designer's seal.
i. City of Oak Ridge Fire Department identified as emergency response organization.
j. Occupancy type(s).
k. Construction type.
l. Total floor area of each occupancy, with actual design area compared to allowed area, and explanation of any increases.
m. Actual building height/stories, with actual height/stories compared to allowed, and explanation of any increases.
n. Structural fire ratings.
o. Identification of fire suppression systems and areas covered.
p. Identification of fire alarm signaling systems and areas covered.
q. Emergency lighting provisions.
r. Any smoke management provisions.
s. Any special systems or protection approaches.
t. Hazardous materials identified by hazard class, storage areas, use areas and systems, both inside and outside the building envelope as needed.
u. Water supply information for fire protection.
v. Alternative design, modifications, methods, systems, or construction to document rationale and acceptance.

D. The code footprint shall be developed as early in the initial design process as possible, and shall be the code compliance review submittal. It shall be the documentation method for any changes which involve the non-structural code aspects of the design. It shall be used to track and communicate design changes, for review submittals, and to capture and portray the as-built facility code compliance status. It shall be modified as needed during the design and construction process to accurately reflect current facility design status, and shall be part of the required as-built documentation.

## 7.7 Requirements for Review Submittals

A. Formal design reviews shall be performed by the ORNL and the City of Oak Ridge, and documentation of acceptance of the reviewed design will be accomplished before any work involving the reviewed material begins. The reviews will be conducted on submittals which meet the following requirements as follows:
1. Code footprint drawings for general non-structural code compliance as described in this section.
2. Plans and specifications for fire protection systems meeting the documentation requirements of the pertinent code and/or standard.

## 7.8 Roles and Responsibilities

A. The designer shall be responsible for compliance with the requirements in the applicable codes, standards, and referenced material, regardless of whether or not any reviews are conducted, and regardless of any acceptance or rejection of any review items or elements. Any features or elements of the design solution which meet the intent of the code and standards, and is accepted by the AHJ as an appropriate alternative or equivalent approach to compliance, in accordance with IBC 104.11, shall be documented according to the documentation requirements in this section.

B. The designer's area of responsibility includes all aspects of compliance with the I-Codes package and references and NFPA 1 and references such as identification and characterization of hazards, application of the appropriate referenced codes and standards, definition of occupancy, technical documentation/justification of particular compliance elements as needed, and all other aspects of facility design. It shall be the designer's role to evaluate any alternative or equivalent methods, materials, or systems proposed for use in the design, and the designer shall present justification documentation to the AHJ for acceptance according to the documentation requirements in this section.

C. Design, installation, testing, and acceptance of fire protection systems shall be performed by entities meeting the requirements of Tennessee state law concerning licensing and practice standards for work involving fire protection systems. Compliance with the applicable codes, standards, and references in the I-Code package shall be demonstrated in design, installation, testing, and acceptance of fire protection systems.

END OF SECTION 7 FIRE PROTECTION

# SECTION 8

# ELECTRICAL

## 8.1 Developer Coordination

A. Developer shall coordinate with the selected equipment supplier to determine and provide the proper electrical distribution equipment and provide under slab raceways between the power distribution equipment and process line equipment.

B. Developer shall coordinate with the selected equipment supplier to provide under slab raceways for power circuits between process line equipment and process line motor control centers.

C. Developer shall coordinate with the selected equipment supplier to provide under slab raceways for control and instrumentation among process line equipment and between process line equipment and process line motor control centers, process line programmable logic controllers, and control room equipment.

## 8.2 Specific Requirements

A. The facility shall be provided with three unit substations. Two unit substations shall provide power to the process line. One unit substation shall provide power to mechanical systems that support the process line and balance of plant (lights, receptacles, building HVAC, etc.). The substations shall be sized to provide for a future advanced process line.

B. Substation #1 (Process Line) shall be rated 2000KVA. The substation shall serve a 277Y/480V, 2500A switchboard. The switchboard shall serve the oxidation ovens (first installed process line and a future process line), including associated heaters, circulation fans, etc. The switchboard shall allow provisions for a quantity of five 250A frame breakers and one 800A frame breaker.

C. Substation #2 (Process Line) shall be rated 1500KVA. The substation shall serve a 277Y/480V, 2000A switchboard. The switchboard shall serve the balance of the (first installed and future) process line. The switchboard shall allow provisions for a quantity of ten 250A frame breakers and one 600A frame breaker.

D. Substation #3 shall be rated 1500KVA. The substation shall serve a 277Y/480V, 2000A switchboard. The switchboard shall serve the mechanical systems and balance of plant. The switchboard shall allow provisions for a quantity of ten 250A frame breakers.

E. A 450KW/562.5KVA, 277Y/480V emergency generator shall be provided. The generator shall be Class 24, Level 1, Type 10.

F. A 150KVA UPS and associated distribution equipment shall be provided. The UPS shall be served by standby power (generator).

G. Equipment Layout
   1. The site and facility layout shall include an area to conveniently provide a future electrical distribution/MCC room that will serve a future process line. Provide underground raceways as required to serve this future electrical/MCC room from the three switchboards.
   2. The first installed process line may be expanded at a future date. The expansion will take place on the creel end of the process line. No electrical equipment, raceways, etc. shall be installed on the wall adjacent to the creel end of the process line.
   3. Provide an alarm at all air locks to provide a local visual and audible alarm when both doors are open.

## 8.3 General Design Requirements

A. Electrical safety shall be the foremost consideration in the design of the facility. Consideration shall be given to the electrical design to minimize the necessity of working on or near energized parts and equipment during construction, operation, and maintenance activities.

B. The electrical design and all electrical installation work shall be in accordance the National Electrical Code (NFPA 70), the National Electrical Safety Code (IEEE C2), National Fire Protection Association (NFPA) codes, Occupational Safety and Health Act (OSHA) standards as well as other applicable federal, state, and local codes and standards, as well as codes and standards required by the local Authority Having Jurisdiction (AHJ). All materials and equipment furnished shall be new, conform to applicable ANSI, IEEE, NEMA, NFPA and UL standards.

C. Design Analysis And Calculations
   1. Calculations shall include but are not limited to the following:
      a. Short circuit currents.
      b. Overcurrent device coordination.
      c. Flash protection boundary and incident energy exposure for panelboards, switchboards, motor control centers, switchgear, etc., operating at 600V or less. Provide arc flash warning labels on all electrical equipment that include required PPE for all boundaries listed in NFPA 70E.
      d. Connected load, demand load, demand factor, and diversity factor for overall building and for emergency standby and uninterruptible loads.
      e. Voltage drop.
      f. Conductor capacities.
      g. Lighting footcandle level.
      h. Electric heat tracing (including in rush current).
      i. Raceway/cable tray sizes.
      j. Conduit sizes.
      k. Grounding.
   2. Hard copy and electronic files (in native format) for calculations and design analysis shall be provided. SKM software shall be utilized for short circuit, overcurrent coordination, and flash protection boundary analysis.
   3. Initial calculations for short circuit analysis, and load calculations may be provided using SKM default libraries. The SKM model shall be updated using the specific electrical

equipment provided. This updated analysis shall be used for overcurrent device coordination, arc flash analysis, and PPE requirements. A hard copy and electronic files of the updated SKM model (pdf and complete native files) shall be provided.

D. Electrical Energy Usage Metering

1. Provide sub-metering for the three main switchboards and for three future loads. The metering shall be E-mon D-mon with interval data recorder and E-mon energy software or equivalent. Metering shall provide real time KW indication and shall include data logging. Provide necessary software keys and equipment to download data via a USB port. Provide an external USB port on the metering cabinet exterior.

## 8.4 Power Distribution Systems

A. Medium Voltage Metal-Clad Switchgear

1. Outdoor medium voltage metal-clad switchgear shall be circuit interrupter switch type. Switchgear shall provide a window to verify switchblades are in the open position. One set of spare fuses shall be provided for each switch. 15KV surge arresters shall be provided. Buses shall be copper with silver plating at all contact points.

B. Medium Voltage Transformers

1. Transformer efficiency shall be in compliance with 10 CFR 431, Part III, final rule 72 FR 58190.
2. Transformers shall be FM approved and specified with the following required features: the KVA rating (dry type transformers shall include the ONAN/ONAF/OFAF rating); the voltage rating; the insulation class; the temperature rise; the base impulse level (BIL); the connection configuration (delta-grounded wye, etc.); and any special features (voltage tap requirements, core/winding construction, ventilation fans, etc.). Clearances shall be provided in accordance with applicable ANSI C57 Series Standards, FM data sheets, NFPA 70, and for typical maintenance activities. Heavy vehicle access shall be provided to transformer locations.

C. Low Voltage Metal-Enclosed Switchgear

1. Switchgear shall not utilize tapered horizontal buses. Buses shall be copper with tin plating at all contact points. Switchgear located outside shall be provided with lighting, convenience receptacle(s), and heat.

D. Distribution Switchboards

1. Switchboards shall comply with NEMA PB-2 and UL 891.

E. Distribution Panelboards

1. Panelboard circuit breakers capable of interrupting the available short-circuit current shall be selected. Distribution panelboards shall be furnished with a separate grounding bus for equipment grounds and a solid neutral bus where a neutral is required. Initial design demand load shall not exceed 80% of the panelboard's rated capacity. Provide 20% spare breaker mounting space for future loads.

F. Low Voltage Transformers (600V)

1. Transformer efficiency shall be in compliance with 10 CFR 431, Part III, final rule 72 FR 58190.
2. Interior step-down low voltage transformers (480:120/208 V; 480:120/240 v; etc.) for lighting, receptacle and miscellaneous loads shall be dry type, floor or wall mounted, with a minimum of four full capacity 2-1/2% taps, with two taps above and two taps below rated voltage.

G. Lighting and Power Panelboards
1. Dedicated panelboards for lighting shall be provided.
2. Lighting and power panelboards shall be provided with copper buses and bolt-on circuit breakers.
3. Approximately 20% of the branch circuit breakers installed shall be spares. Individual branch circuit loading shall not exceed 80% of continuous rating, and the combined loads of all the branch circuits of an individual panelboard shall not exceed 80% of the panel's rated capacity. Panelboards shall be furnished with a separate grounding bus for equipment grounds. Neutral buses shall not be grounded at the panelboard except where the panelboard serves as the service entrance equipment.
4. Panel schedules shall be provided for all panelboards and shall indicate which circuits require ground fault protection (equipment and personal), shunt trip, etc.

H. Interior Distribution Voltage Levels
1. Power shall be distributed at 277Y/480 three phase, four wire, grounded and 120Y/208V, three phase, four wire with grounded neutral.

I. Control Voltages
1. All control circuits shall be designed with operating personnel safety as the primary consideration. Control transformers shall be provided such that the control voltage for equipment does not exceed 24VAC.

J. Electrical Distribution Equipment Identification
1. In each building or facility, equipment that distributes electrical power (480V switchgear, 480V motor control centers, 480V panelboards, electrical plug-in busways, distribution switchboards, distribution racks, load centers, lighting and power panelboards; etc.) shall be identified in accordance with ORNL Engineering Standard Electrical System Identification Scheme.
2. Each piece of electrical distribution equipment (switches, starters, panelboards, receptacles, etc.) shall be clearly marked with the voltage, number of phases, source of supply (panel and circuit; etc.), and the equipment being served.

## 8.5 Emergency and Standby Power Systems

A. Distribution System
1. The emergency and standby loads shall be configured such that emergency loads and standby loads (process line and mechanical equipment) are served by separate transfer switches.

B. Emergency Power Systems

1. Emergency power systems shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110 and IEEE 446. The systems shall automatically supply power and illumination essential to human life safety during any interruption of the normal electrical supply. In addition to supplying emergency illumination for safe exiting, emergency systems may also provide power for such functions as ventilation equipment when essential to maintain life, fire detection and alarm systems, elevators, fire pumps, public safety communication systems, and industrial processes where current interruptions would produce serious life safety hazards.

C. Standby Power Systems

1. Standby power systems shall comply with Articles 701 and 702 of NFPA 70. The systems shall supply power to selected loads such as heating and refrigeration systems, data processing and communication systems, ventilation and smoke removal systems, sewage disposal systems, lighting systems, and industrial processes, that when interrupted during a power outage, would create hazards, damage to product or process, or severe monetary loss.

D. Packaged Diesel Generator Sets and Automatic Transfer Switches

1. Emergency and standby power generators shall be exterior concrete pad mounted, diesel engine-generator type, and shall include a weatherproof enclosure, integral 24 hour UL listed sub-base double wall fuel tank with leak detection, battery, battery heater, battery charger and starting system, exhaust silencer, jacket heater, output circuit breaker, microprocessor based control panel and remote annunciator panel. Developer shall provide adequate fuel to perform all on site tests and demonstrations. Developer shall provide a full tank of fuel at facility turn over.
2. Automatic transfer switches for switching a load from a normal power source to an emergency or standby source shall include an integral bypass-isolation switch and microprocessor based control panel.
3. Automatic transfer from emergency or standby source to normal source shall be closed transition.
4. Generator alarm/trouble, generator running, and transfer switch operation shall be monitored by the building automation system (DDC).
5. Automatic transfer switches shall be provided with programmable engine exercisers with option to transfer load to emergency or standby source.

E. Uninterruptible Power Systems

1. Uninterruptible Power Sources (UPSs) shall be provided for those loads requiring guaranteed continuous power. Where used for telecommunication, emergency, or legally required standby systems, installation shall comply with NFPA 70. Applications of UPSs shall comply with IEEE 446 and NFPA 111.

## 8.6 Lighting Systems

A. General

1. Exterior Lighting Systems

a. Exterior lighting systems shall comply with the IESNA Lighting Handbook, and applicable Recommended Practice (RP) manuals. Metal halide shall be provided for parking lot and area lighting. Cut-off type luminaires shall be utilized.
b. Exterior lighting shall be controlled by the same lighting controller used for the high bay area.

2. Interior Lighting Systems
   a. Lighting in the high bay process area shall be metal halide.
   b. Provide recess down lighting in reception area to wash walls suitable for display.
   c. Lighting in all other areas shall be fluorescent, T5 or T8 lamps.
   d. Provide T8 fluorescent troffers in areas with acoustical ceilings.
   e. Provide heavy duty industrial fixtures with wire guards in areas with unfinished ceilings. Except for storage areas, fixtures shall have a nominal 20% uplight component.

B. Lighting Circuit Voltage Levels
   1. Lighting shall operate at 277V.

C. Illumination Levels
   1. Lighting calculations based on the type of luminaire and the number of lamps per luminaire shall be prepared for each area. The lighting level in each area shall be in accordance with the room data sheets.

D. Lighting Controls
   1. The high bay area shall be controlled by a Wattstopper LP8 lighting control panel, equipped with an eight channel group switching card. Provide lighting contactors as required, or utilize a Wattstopper LP24 tub with the necessary contactors. The high bay area lighting shall be split into a minimum of four zones, preferably in rows, to offer multilevel lighting. Provide a control station at every entry into the high bay area that consists of a switch for each zone and a master switch. Switches shall be 3 wire control.
   2. All other areas shall have automatic lighting controls.

E. Lighting Circuits
   1. Wiring for lighting circuits shall be run in conduit. Type MC cable may be used above suspended grid ceilings.

F. Exit Lighting
   1. Exit lighting fixtures shall be provided to identify building exits. Fixtures shall include self-testing and diagnostic features. Self-testing feature shall include a 90 minute test every 6 months. Exit lighting shall comply with NFPA 101 and NFPA 110.

G. Emergency Egress Lighting
   1. Emergency lighting shall be provided by the emergency generator.
   2. In the high bay area, metal halide fixtures providing emergency lighting shall be provided with hot and cold quartz restrike lamps with delay. The emergency fixtures shall not be night light fixtures, but shall be controlled in the same method as normal fixtures using a UL listed relay device such as Wattstopper ELCU-200.
   3. All other areas shall be provided with an emergency circuit to serve emergency fixtures. Fixtures shall be controlled by local control and provided with a UL listed relay device.

H. Personnel Entrance Lighting

1. The exterior of personnel entrance doors shall be illuminated with a wall mounted 70 watt metal halide or 42 watt compact fluorescent luminaire. The luminaire shall be a cut-off type. Conventional wall pack luminaires are not acceptable. Luminaires shall be automatically controlled and be served by emergency power. It shall be permissible to utilize the same lighting control panel that serves the high bay area.

I. Lighting Circuit Identification

1. Electrical service for exit lighting fixtures shall be supplied from a dedicated circuit. These circuits shall be clearly identified on panel directories as supplying exit lighting fixtures.

## 8.7 Grounding And Bonding

A. General

1. A grounding electrode system, in conjunction with grounding and bonding requirements for electrical systems, building structural steel, and facility equipment, shall be provided and installed per NFPA 70. The supplemental grounding electrode(s) required by NFPA 70 shall be either a ground grid.
2. Ground grids, loops, ground buses, etc., shall be tested by an independent testing agency using the fall of potential method in IEEE Standard 81.

B. Ground Grid

1. Ground grid systems shall consist of a buried No. 2/0 bare copper cable and driven ground rods located around the perimeter of the building. The cable shall be buried a minimum of 30 in. deep and be located a minimum 3 ft. away from the building. Driven ground rods shall be 3/4 in. diameter X 10 ft long and be spaced at nominal 25-ft intervals around the perimeter of the building. The grounding system shall be designed and tested so that the resistance to earth does not exceed 1 ohm.

C. Ground Loop

1. Unless directed otherwise by a local utility, provide a minimum of four ground rods, 3/4 in. diameter X 10 ft long, at each medium voltage transformer, switchgear, etc., and a ground loop consisting of a buried No. 2/0 bare copper cable circling the equipment pad. For medium voltage transformers with a secondary neutral bonded to the transformer enclosure, do not connect the ground loop to any facility ground grid to prevent paralleling of the service entrance grounded (neutral) conductor. Ground loops shall be designed and tested so that the resistance to earth does not exceed 5 ohms.

D. Grounding Electrode Conductor and Bonding Jumpers

1. The size for grounding electrode conductors and bonding jumpers shall be, as a minimum, No. 2/0 bare copper or larger, as required by NFPA 70, Article 250. Grounding electrode conductors and bonding jumpers shall be extended from the ground grid to the electrical service entrance equipment, structural steel, internal step-down transformers, ground buses, and to dedicated telecommunication equipment areas. The secondary neutral of step-down transformers shall be grounded in accordance with Article 250 of NFPA 70.

E. Structural Bonding and Ground Buses

1. For facilities that utilize a ground grid, the structural steel in each building shall be bonded at each alternate column by means of a No. 2/0 bare copper cable. Ground buses, as required, shall be connected to the ground grid or triad by means of a No. 2/0 bare copper cable. Ground inserts shall be used where ground cables extending through the surface of the concrete would be exposed to mechanical damage.

F. Ground Pads

1. Provide ground pads along both sides of the process line and in a corresponding manner where the future process line will be installed. Ground pads shall be placed every 20 feet. Coordinate specific locating with equipment vendor.

G. Equipment Grounding and Bonding

1. Equipment which is electrically connected such as panelboards, junction boxes, safety switches, terminal boxes, transformers, etc., shall be grounded and bonded with a dedicated equipment grounding conductor run with the circuit conductors supplying the equipment as stated in Article 250 of NFPA 70. Metallic raceways, enclosure, etc., shall be bonded together to form an effective ground fault current path per NFPA 70, article 250.
2. Other equipment such as motor control centers, switchboards, main distribution panels, etc., shall be connected to the grounding grid with No. 2/0 bare copper cable.
3. Non-electrical equipment as defined in article 250 of NFPA 70, which is required to be grounded, may be connected to ground buses strategically located on columns or walls.

H. Transient Voltage Surge Suppression (TVSS)

1. Transient voltage surge suppression shall be provided as a system in that multiple devices shall be installed at different levels of the power distribution system in order to provide a total coordinated, engineered system. TVSS products shall comply with UL 1449, IEEE 62.41, and IEEE 62.45.

I. Signal Reference Grid (SRG)

1. SRG's shall be installed in accordance with NFPA 70 and IEEE 1100, Recommended Practice for Power and Grounding Electronic Equipment.

## 8.8 Miscellaneous Systems

A. Lightning Protection

1. A lightning protection system shall be provided. See section 7.0, Fire Protection, for requirements of lightning protection systems for buildings and structures.
2. Electric power and communication services shall have lightning and surge protection.

B. Electric Heat Trace Systems

1. Electric heat tracing systems for exterior piping and vessels shall be provided as required and installed in accordance with Article 427 of NFPA 70. Signs and labels shall be provided on pipelines and vessels to indicate the presence of heat trace systems. Branch circuits serving heat trace circuits shall be supplied with equipment ground fault protection (Class B). Electric heat trace cable shall be self-regulating type with tinned

copper braid and overall jacket. Splicing of heat trace cable under pipe insulation is unacceptable. Heat trace systems shall be verified by a megger test before energization. Start up testing shall include in-rush and steady state current measurements.

C. Access Control, Security, and Video Surveillance
1. Dedicated branch circuits shall be supplied for access control, security, and video surveillance systems. Circuits shall be on standby power.

## 8.9 Equipment

A. Conductors And Cable
1. General
a. The color coding system for branch circuits shall be provided at all lighting and power panelboards in facilities where more than one nominal voltage system exists.
b. Phase and neutral (grounded) conductors shall be identified by circuit number at all accessible locations.
c. All conductors for interior electrical systems shall be copper. Conductors for power and lighting branch circuits shall not be smaller than No. 12 AWG.
d. Megger tests are required for all 600V cables #4 and larger and may be performed by the developer or independent testing agency. Hi-Pot tests for all medium voltage cables are required and shall be performed by an independent testing agency.
2. Multiwire Circuits
a. Multiwire circuits may be utilized for lighting circuits only. Where multiwire circuits are utilized, multi-pole breakers (common trip) shall be provided to disconnect all ungrounded conductors sharing a common neutral.
3. Power and Lighting Cables
a. Type MC cable, per Article 330 of NFPA 70, may be used whenever practical in lieu of conduit and conductors in concealed locations. MC cable may be used to supply receptacles, recessed and mounted in steel stud partitions.
4. Medium Voltage Cables
a. Medium voltage cables shall be in accordance with NEMA WC74. Medium voltage splices and terminations shall use compression type lugs and butt splices, with cold shrink type termination kits. Medium voltage cable shall be rated 90 degrees C, 133% insulation level, copper tape shielded.
b. Medium voltage riser cables at power poles shall be routed entirely in galvanized rigid steel conduit .
5. Inspections and Tests
a. Inspection and testing of electrical equipment, such as motors, switchgear, lighting, power, and distribution panels, MCCs, power receptacles, power and lighting transformers, wire and cable, ground systems, etc., shall be provided for in the specifications.

B. Conduit And Raceways
1. General

a. Raceways that penetrate fire-rated assemblies shall be metallic. All through penetration fire-stops shall be UL listed assemblies and be selected from the UL Fire Resistance Directory. Raceways shall be 1/2-in. minimum in diameter. Raceways embedded in concrete or masonry shall be 3/4-in. minimum.

2. Rigid Galvanized Steel Conduit and Intermediate Metallic Conduit
   a. Rigid galvanized steel (RGS) conduit or intermediate metallic conduit (IMC) generally shall be used in industrial areas where conduits are exposed to damage from forklifts, trucks, cranes, etc., or where there is the possibility of leaking oil or water. RGS conduit or IMC shall also be used in classified locations and for outdoor and underground installations.
3. Electrical Metallic Tubing
   a. Electrical metallic tubing (EMT) shall generally be used in office and similar areas and also in industrial areas where physical damage is unlikely. EMT shall not be installed in wet areas, underground, or outdoors and shall not be encased in concrete.
4. Aluminum Conduit
   a. Aluminum conduit shall be used for high-frequency (HF) circuits where steel will cause magnetic problems or in atmospheres where steel conduit is unsuitable. Aluminum conduit shall not be installed underground, encased in concrete, or where the atmosphere is corrosive to aluminum.
5. Nonmetallic Conduit
   a. Nonmetallic conduit may be used where allowed by NFPA 70.
6. Flexible Conduit
   a. Flexible metal conduit shall be used for terminating rigid raceway at motor terminal boxes or other equipment subject to vibration and/or mechanical adjustment. It also shall be used for connection between junction boxes and recessed lighting luminaires. Liquid-tight flexible conduit shall be used outdoors and indoors where there is the possibility of leaking fluids.

C. Underground Conduits
1. General
   a. All underground conduit shall be installed within a ductbank. The exception would be for direct buried conduit serving receptacle and lighting circuits not routed under roadways.
   b. Underground ductbanks shall be concrete encased and reinforced per ORNL Engineering Standard ES-8-4. Heavy reinforced duct banks shall be provided under roadways.
   c. Underground conduits emerging from grade shall be galvanized rigid steel.
   d. Provide a tracer wire for all conduits and ductbanks that include other than medium voltage circuits. See Civil section for tracer wire requirements.
   e. Specifications shall indicate that as-built survey information (location and elevation) shall be provided for all underground direct buried conduits and ductbanks.
2. Medium Voltage Circuits
   a. Provide a bare #2/0 copper cable on top of ductbanks containing medium voltage circuits.
   b. Underground conduits for medium voltage circuits shall be 5 inch. Underground conduit sweeps for medium voltage circuits shall have a 48 inch radius.

3. Telecommunication Circuits
   a. Underground telecommunication conduits shall be 4 inch.
   b. Underground conduit sweeps for telecommunication circuits shall have a 36 inch radius.

D. Receptacles
1. General
   a. All receptacles shall conform to NEMA WD-1. All receptacles shall be industrial specification grade. Duplex receptacles shall typically be fed from power panelboards with 20A branch circuits with a maximum of six duplex receptacles per circuit.
2. 120V Receptacles
   a. As a minimum, 120V receptacles shall be provided in accordance with NFPA 70 and be consistent with established engineering practices.
   b. Duplex receptacles installed on finished walls shall be recessed. Duplex receptacles installed in unfinished areas shall be surface mounted in cast boxes.
   c. Duplex receptacles shall be provided nominally at 40 ft. in the high bay process area. No more than 3 receptacles shall be installed per circuit.
   d. Duplex receptacles shall be installed every 25 ft along corridors in the building. A duplex receptacle fed from a separate dedicated circuit shall be provided at each proposed area for photocopier equipment. Additional receptacles for copier/fax/printer rooms shall be provided as required to serve the proposed equipment.
   e. Where applicable, duplex receptacles shall be provided in the fire protection riser room, electrical/mechanical equipment room, janitor's closet, and the main communications equipment area.
   f. Two piece metal multioutlet assemblies similar to Wiremold 4000 series shall be provided above laboratory benches in the laboratories. Receptacles shall be provided at 18" on center, 4 receptacles per circuit. Provide a barrier in the raceway to provide a channel for communication circuits.
3. 208V and 240V Receptacles
   a. Provide two 208V, three phase receptacles in laboratories and chemical mixing rooms.
4. 480V Receptacles
   a. Provide three 480V, three phase receptacles in the high bay process area. Receptacles shall be pin and sleeve type, rated 600V, 60A, and shall be compatible with Crouse-Hinds Cat. No. APJ6485 plug. Receptacles shall be provided with integral/interlocked disconnect switch.
5. Standby Receptacles
   a. Provide two standby power circuits serving 6 receptacles in the electrical service and MCC area.
6. Exterior Receptacles
   a. Surface mounted exterior receptacles shall be housed in cast type conduit boxes.
   b. Exterior outlets shall be provided with "in-use" metallic covers that form a raintight assembly with their respective boxes and that shall maintain the raintight protection while the attachment cord and plug are in place. All exterior receptacle

7. Motor enclosures shall be drip proof for indoor dry locations and totally enclosed or totally enclosed fan cooled for outdoor or other wet locations, except where special conditions require.
8. Variable Speed Drives (VSDs) shall be provided where motor speed requirements vary widely during normal operation or for energy conservation in regards to HVAC systems. In all cases, the driven motor shall be selected in accordance with the drive manufacturer's recommendations to ensure a coordinated system and to avoid overheating the motor. Motors shall be premium efficiency motors.
9. Variable Speed Drives (VSDs) shall be provided with harmonic filters meeting the requirements stated in ORNL Engineering Standard ES-8-20, Harmonic Limits on Non-Linear Loads.

E. Industrial Control Panels
1. All control panels shall meet the requirements of NFPA 70, Article 409, and UL 508A.

END OF SECTION 8 - ELECTRICAL

# SECTION 9

# COMMUNICATIONS

9.1 Project Specific Criteria

9.2 Design Standards

A. Work Smart Standards
   1. NFPA 70, National Electric Code

B. Additional standards include but are not limited to the following:
   1. TIA/EIA-568-B.1, Commercial Building Telecommunications Cabling Standard - Part 1
   2. TIA/EIA-568-B.2, Commercial Building Telecommunications Cabling Standard - Part 2
   3. TIA/EIA-568-B.3, Optical Fiber Cabling Components Standard
   4. TIA/EIA-569-A, Commercial Building Standard for Telecommunications Pathways and Spaces
   5. TIA/EIA-607, Commercial Building Grounding and Bonding Requirements for Telecommunications

9.3 General Requirements

A. Telephone service, computer local area network (LAN), public address (PA) systems, security / access control systems, and fire alarm systems shall be provided in the facility.

B. Telecommunications circuits and equipment shall be installed to satisfy the requirements in sections 2.0 through 11.0 and the requirements in the room data sheets. This equipment and these circuits shall be tested to verify that they satisfy the requirements in sections 2.0 through 11.0 and the requirements in the room data sheets.

C. Design for telephone service shall be coordinated with the local service provider.

9.4 Communications Architecture and Room Requirements

A. Telecommunication Room (Telecomm Room)
   1. Provide a dedicated telecommunication room for telephone, LAN, PA, security and fire alarm equipment.
   2. The Telecomm Room shall be located within the Electrical/MCC envelope.
   3. The Telecomm Room shall be a minimum of 100 square feet.
   4. The Telecomm Room shall be located so that the farthermost telecommunication outlet is at or below 250 feet.
   5. Fire retardant plywood shall be installed on all walls to allow installation of equipment and patch panels. The plywood shall be installed such that the fire rating label is visible.

Once the Company has approved the plywood installation, it shall be painted to match the walls.

6. Overhead cable trays shall be installed to allow cables to be run between the fire retardant plywood and equipment racks.
7. Lighting and convenience outlets shall be in accordance with required codes. Lighting shall be arranged to provide 50 foot-candles in the aisles between the equipment. All lights shall be supplied from emergency power.
8. All receptacles in the Telecomm Room shall be served by standby power. Receptacles that serve LAN equipment shall be served by a UPS.
9. Underground telecommunication ducts and conduits extending outside the building to manholes and other facilities shall originate in this room.
10. Grounding provisions shall be made in the Telecomm Room per TIA/EIA-607

B. See Section 10 - Security, and/or Room Data Sheets for additional requirements for the Telecomm Room.

## 9.5 Cable Trays and Wireways

A. Building areas shall be served by either an overhead cable tray system or enclosed wireway system. This system must be accessible for servicing, adding, or removing cable, fiber, etc.

B. Cable trays and wireways shall be sized to allow 100% spare capacity with pull ropes provided in all cabe tray sections back to the Telecomm Room at completion of the project.

C. Cable trays and wireways shall be located in corridors adjacent to offices and other spaces where data/communications or wireless networking drops will be provided.

1. Cable trays and wireways shall not be located over conference rooms, kitchen area, restrooms, offices and other normally occupied areas to avoid having to interfere with room activities when new cables and circuits are installed.

## 9.6 Circuits Within Building

A. Voice and LAN (data) cabling from the Telecomm Room to data/comm outlets shall be provided and shall consist of the following, at a minimum:

1. Voice cabling shall be one continuous non-spliced, 4-twisted pair, #24 AWG solid copper, UL or ETL Category 6A, unshielded. Cable shall be installed, terminated, tested, and labeled in accordance with applicable TIA/EIA standards. To ensure performance of Category 6A cable and terminations, test results shall be provided to the Company.
2. LAN cabling shall be one continuous non-spliced, 4-twisted pair, #24 AWG solid copper, UL or ETL Category 6A unshielded cable. Cable shall be installed, terminated, tested, and labeled in accordance with applicable TIA/EIA standards. To ensure performance of Category 6A cable and terminations, test results shall be provided to the Company.
3. Terminate each cable in a RJ-45 jack at data/comm outlets and within a patch panel inside the telecomm room.
   a. Provide 1 inch diameter metallic conduit from data/comm outlet through the wall to area above ceiling and terminate conduit with plastic bushing. Leave 12” of

excess cable coiled up in ceiling space above each outlet location to allow future re-termination of cable. Coordinate outlet location(s) with furniture placement.

B. Data/comm outlets shall be double-ganged and shall be flush mounted. If flush mounting is not practical, a surface mounted box may be used if approved by the Company. Faceplates and/or fiber jack installations shall be sloped /angled type to maintain proper bend radius for work area cable and have four available modular inserts. Typically, wall mounted data/comm. outlets are to be located eighteen inches above the floor with final location being contingent on furniture location. Modular inserts shall be filled as follows:
   1. Two Top Positions - Two RJ45 data modular jacks that meet or exceed the latest TIA/EIA standard for Cat 6A horizontal cabling using four pair cables.
   2. Two Bottom positions - One RJ45 voice modular jack that meets or exceeds the latest TIA/EIA standard for horizontal Cat 6A cabling and one optional voice jack/blank.

C. The number of data/comm. outlets per room shall be per the room data sheets or as indicated elsewhere in the design requirements.

D. Unless otherwise noted on room data sheets or drawings, each data/comm outlet shall have one voice circuit and two data circuits.

E. Provide two communication outlets in each office on opposing walls with the final arrangement approved by Company before completion of design. Each outlet shall have one voice circuit and two data circuits.

F. Terminations for fiber optic cables within the building shall be fusion type or SC connectors.

## 9.7 Incoming Circuits

A. Provide equipment racks and patch panels to allow termination of an incoming communication service of 24 single mode and 24 multi-mode fiber optic cables.

B. Provide wall space to serve surge protectors and punch down blocks for an incoming telephone service of 50 pairs. Provide a ground bus at this same location.

## 9.8 Exterior Communication Raceways

A. Install a duct bank consisting of three 4” diameter schedule 40 PVC conduits from the exterior of the facility to the Telecomm Room. Install inner duct in all of the three conduits. All conduits shall be installed with 36” radius elbows.

B. Inner ducts shall be MaxCell fabric type with cable pulling tape in all cells. Each inner duct shall provide for three cable placements (cells). Three inner ducts shall be installed per conduit.

C. Install pull rope in vacant conduit.

D. Push inner duct and pull ropes back into the end of duct runs and install cap to prevent mud and water from seeping into duct.

E. Duct banks shall be concrete encased topped with red dye. Duct banks in roadways shall be structurally reinforced.

F. Installation of all cables shall be in accordance with the manufacturer's recommendations. Recommended pulling tension, bend radius, and other critical parameters shall not be exceeded.

## 9.9 Telephones

A. Provide a fully functioning PBX telephone system and telephones.

## 9.10 Network Equipment

A. Provide rack space for the installation of network equipment. The Company will furnish and install currently available technology networking equipment to provide networking capability for data/com outlets located in the building. The Company will connect networking equipment to the ESnet backbone.

## 9.11 Public Address System

A. Provide a PA system to serve the entire facility. The PA system shall also be capable of connection to the PBX phone system for local paging.

B. The number of speakers required for adequate coverage of an area shall be based upon a comfortable listening level of paging for personnel in close proximity to speakers.

## 9.12 Telecommunications Equipment Cooling

A. Adequate cooling shall be provided in the Telecomm Room to offset heat generated by networking and other telecommunication equipment. See Section 5 – HVAC for more requirements.

END OF SECTION 9 COMMUNICATIONS

# SECTION 10

# SECURITY

10.1 Project Specific Criteria

10.2 Work Smart Standards

A. NFPA 70, National Electric Code.

B. NFPA 101, Life Safety Code.

C. International Building Code, 2006 (IBC).

D. Americans with Disabilities Act (ADA), guidelines (ADAAG).

10.3 General Security and Access Control Requirements

A. Building access control shall be provided as follows:
   1. The entire building perimeter shall be controlled by a Hirsch system. Perimeter entrances shall be provided with proximity card readers.
   2. Perimeter entrances (doors, roll up doors, roof hatches, etc.) not required to have card readers shall be monitored using magnetic door switches.
   3. The following areas shall be provided with proximity card readers:
      a. Telecommunication room.
      b. Electrical/MCC room.
      c. Laboratories.
      d. Control room.
      e. Offices (each office and entrance into office area).
      f. Entrance(s) into the process area.
      g. Storage areas.
      h. Mezzanine gates.
      i. Control consoles (16 each); the system shall provide a dry contact for interface into the console to permit “waking up”.

B. All security features and functions will comply with the requirement of the IBC and ADA and shall not create any impairment of the Means of Egress.

C. Entrances controlled using proximity card readers shall be provided with electric door strikes or latches, and magnetic door switches.

10.4 Controllers for Alarms and Access Controls

A. The controller(s) for access control shall be a Hirsch Model 8. One Model 8 is capable of controlling 8 doors. Provide space in the Telecommunications Equipment Room for the quantity of Model 8's required.

B. The controller(s) for alarms shall be a Hirsch Model 16. Alarm control is typically required for perimeter entrances that do not have proximity card access (roll up doors, roof hatches, etc.). Provide space in the Telecommunications Equipment Room for a minimum of one Model 16.

C. One wall mounted fiber optic patch panel cabinet shall be provided in the telecommunications room specifically for the Hirsch controllers. The cabinet shall be similar to Hubbell catalog number FCE4SP. Provide adapter panels to terminate 12SM and 12MM fiber optic cables.

D. Provide all necessary software for a standalone alarm and access control system. Provide all necessary software and hardware for credential enrollment. Provide an initial supply of 50 proximity cards.

E. Provide space for one empty Hirsch Model 8 enclosure adjacent to the alarm and access control panels to house communications hardware for possible connection to a remote monitoring location. The enclosure shall be located between the fiber optic patch panel and the line up of Hirsch controllers.

F. Three 120-V AC, 20 amp dedicated branch circuit, shall be provided for the controllers and enclosure for communications hardware. These circuit shall be supplied by standby power and shall be installed in metal conduit. Additional standby branch circuits shall be supplied for remote located power supplies serving electric latches.

10.5 Access Controls

A. Security Switches
   1. Provide at exterior doors, interior doors, telecommunication rooms, electrical rooms, mechanical rooms, and other doors at access control locations identified in the room data sheets and Architectural sections, high security balanced magnetic switches wired to a junction box located above the door.
      a. Switches shall be provided and installed by the Company.
      b. Provide one #22 gauge twisted, shielded pair, Belden Cat No. 8761 from the junction box to the Model 8 controller location.
      c. Double leaf door installations shall provide rough in and wiring for two switches, only one home run is required.

B. Proximity Card Readers
   1. Provide at exterior doors, interior doors, telecommunication rooms, electrical rooms, mechanical rooms and other doors at access control locations identified in the room data sheets and Architectural section 4, proximity card readers and door strikes wired to a Model 8 controller.

2. Proximity card readers consist of a proximity card reader and an interface board.
   a. Card readers shall be installed in accordance with ADA standards.
   b. Provide rough in and wiring from the interface board (located above the door) to the controller utilizing 2 #22 gauge twisted pair cable with overall shield, Belden Catalog No. 9302.
   c. The proximity card reader can be wired to the interface board via a factory pigtail.
3. Provide separate card readers for electric door operators used for handicap entrance. This will require using two zones of the Model 8 for doors with electric door operators.

C. Door Hardware
1. Power supplies for electric latches and strikes shall be served by standby power..
2. Provide wiring from the power supply to the latch or strike via one 18 gauge twisted pair unshielded cable, Belden Catalog No. 8461. Power supplies for electric strikes are typically located at the controller location. Power supplies for electric latches are required to be located close to the door due to excessive in rush current. Provide one 18 gauge twisted pair unshielded cable from the remotely located power supplies to the Model 16 controller location.

## 10.6 Alarms

A. Security Switches
1. Exterior doors, roll up doors, roof access hatches, and other doors without access controls shall have high security balanced magnetic switches wired to the Model 16 controller.
   a. Provide wiring from the switch to the Model 16 controller location utilizing one #22 gauge twisted, shielded pair, Belden Cat. No. 8761.

## 10.7 Video Surveillance

A. Provide a fully functioning video surveillance system to monitor exterior perimeter entrances, front personnel entrance, receiving/shipping, parking areas, reception area, high bay process area, MCC room, control room and interior corridors.

B. A DVR/Multiplexer shall be provided and shall have the following capabilities:
1. 16 Channel (minimum), 300 GB hard drive.
2. CD RW burner.
3. 240 FPS recording (maximum).
4. Full triplex, TCP/IP remote interface to allow play, recording, and playback, including all required software.

C. Color Cameras
1. Provide auto iris lenses for all cameras. Focal length shall be determined according to required field of view for each area. Camera lux to be determined per camera location. Provide camera power supply suitable for 16 cameras.

D. Monitors

1. Provide two 17” LCD flat screen monitors, including wall mount or ceiling mount hardware as required. Monitors shall be located in the reception area and the control room.

10.8 Wiring

A. All cables for the Hirsch access control and security system shall be installed in metal conduit between the end device and the controller. If conduit for these circuits must be run exposed, it shall be routed in the area within the security zone.

10.9 Drawings and Shop Drawings

A. Drawings shall be developed in accordance with section 13, Company Interface.

B. Drawings shall include conduit plans, schedules, details, and legends.
   1. Schedules shall be provided for each Model 8 and Model 16 controller. Controller schedules shall include panel zone (door) number, door number (per architectural drawings), reference to typical installation detail, and reference to the architectural hardware set.
   2. Typical elevation details shall be provided for each type of installation, which shall include wiring interconnection diagrams for devices and controllers.

END OF SECTION 10 SECURITY

# SECTION 11

# COMMISSIONING

## 11.1 General

A. Guidance:
   1. Federal Energy Management Program's (FEMP) – "Building Commissioning Guide", see http://www.eren.doe.gov/femp/techassist/bldgcomgd.html
   2. Whole Building Design Guide – see www.wbdg.org

## 11.2 Procurement for services of a Building Commissioning Agent.

A. The Seller shall provide the statement of work to procure the services of a Building Commissioning Agent (BCA).

B. The Developer will contract directly with the BCA for services with Company approval.

C. The BCA will be available prior to the 30% design review.

D. The BCA will be a member of the Building Commissioning Association.

E. The BCA will prepare a commissioning plan and specification (including system verification testing and functional performance testing) that corresponds to the construction schedule and submit for Company approval.
   1. The BCA will follow the design phase and construction phase of the project and perform any re-commissioning / Warranty Expiration activities as specified.
   2. The BCA will provide the Facility Systems Manual and coordinate required operator training.

## 11.3 Commissioning Plan

A. The commissioning plan shall address the requirements identified in the Room Data Criteria Sheets, Code requirements, and Sections 2 through 10 of this document, the design basis document, and the construction specifications and drawings.

B. The commissioning plan shall include system verification testing and functional integrated testing that will be performed on the following systems, as a minimum:
   1. HVAC
      a. All air-water-refrigerant based systems for heating, cooling and refrigeration service shall be functionally tested to verify that all equipment and controls are operating as indicated in the design documentation and in accordance with manufacturer's recommendations and requirements. System operation and controls shall be verified for heating and cooling season operation, start up and shut down under normal, conditions, start up and shut down in off normal

conditions, star up and shut down in emergency conditions and loss of power conditions.

2. Plumbing
   a. Building systems (potable water, sanitary sewer, etc).
   b. Associated site utility systems (potable water, sanitary sewer, (etc).
   c. Domestic water heaters and recirculation system.
3. Fire Protection
   a. Building systems (fire alarms, fire alarm panels, sprinklers, scrams, early warning smoke detection, interlocks, etc.).
4. Electrical
   a. Building systems (power, lighting, metering, wiring devices, grounding, etc). Including DC high potential voltage tests and megohm insulation resistance measurements for medium voltage cable, low voltage cable and transformer megohm insulation resistance measurements.
   b. Emergency and standby power systems (UPSs, generators, auto-transfer switches, etc.) Perform load tests for UPSs and generators. Perform operational tests for auto-transfer switches and UPS transfer function.
   c. Associated site utility systems (power).
5. Communications
   a. Building systems (verify performance of fiber, voice, and data cables and terminations, wireless and public address systems, etc).
6. Security
   a. Building system (verify that cameras, card readers, door switches, and electrically operated door hardware operates properly).

C. System Verification Testing
1. System verification testing shall be required to assure the component and system minimum readiness requirements have been met prior to start up and functional testing.
   a. Check equipment operation and configuration
   b. Verify EMS calibration and operation
   c. Verify system efficiency/performance
   d. Testing hierarchy for system verification testing is suggested as follows.
      1) Sensor and actuator calibration
      2) Point-to-point verification
      3) Single control loops such as the following.
         a) VAV terminal units
         b) Lab hoods
         c) Energy recovery units
         d) Coils
         e) Fans
         f) Other
      4) System interlocks including the following.
         a) Fire
         b) Security
         c) Safety
         d) Occupancy
         e) Other
      5) Intersystem operation as noted in the following examples

a) Central plant
b) Air handling systems
c) Emergency power
d) Other

D. Functional Performance Testing
1. Functional performance testing shall include all modes and sequences of operational control, all interlocks, conditional control responses, and all off normal and emergency operations. Sequences of control shall be verified and deficiencies noted and corrected.
2. Functional performance test procedures shall describe detailed sequential steps necessary to set control parameters and test systems and components throughout all intended ranges of operation.
3. Functional performance test procedures shall start at the basic component level operations and progress up the hierarchy of operations and system complexity. Suggested steps for functional performance test procedures are noted as follows.
   a. Record of existing settings
   b. Sensor calibration checks
   c. Device calibration checks
   d. Test functions
   e. Record Deficiencies Found

## 11.4 Design Phase Responsibilities

A. The BCA design phase responsibilities shall include the following minimum scope.
1. Review the design criteria/RFP documents prior to design commencement.
2. Review and comment design drawings, calculations, and specifications at 30/60/99/CFC submittals.
3. Review design basis established by the Company and A-E.

## 11.5 Construction Phase Responsibilities

A. The BCA construction phase responsibilities shall include the following minimum scope.
1. Review and comment construction submittals for compliance with the project's specifications.
2. Obtain and verify O&M Manual for equipment and systems.
3. Develop and/or track completion of construction checklists as applicable.
4. Construction documentation (record drawings) verified during site visits
5. Commissioning team meetings held to address and resolve quality issues and roadblocks
6. Accomplish and coordinate initial training and O&M walk-throughs.
   a. Initial Training activities may include the following and provide O&M personnel with basis to ask questions and understand contractor training
      1) First session, presented by Commissioning Authority, focuses on the Company's project requirements.
      2) Subsequent sessions focuses on the operational maintenance aspects of the installed equipment and fully integrated systems

## 11.6 Facility System Manual

A. The BCA shall prepare a final Facility Systems Manual (FSM) to include the following minimum documentation:
   1. The systems manual shall provide the information to operators, researchers, maintenance, and engineering personnel. Draft sections shall be submitted to the Company for approval between 30 and 60 days of shop drawing acceptance.
      a. Narrative descriptions of equipment and systems.
      b. System schematics, P&ID's, and control sequences of operation
      c. Final O&M Documentation
      d. Record Drawings
      e. Initial Commissioning Report
      f. TAB report
      g. Training Records
      h. Certificate of Completion

B. The FSM shall be provided in electronic copy (pdf) and **[X]** hard copies.

## 11.7 Seasonal Testing and Training

A. The BCA shall perform required seasonal testing and training.

B. Testing results shall be sent to Company.

## 11.8 Warranty Expiration

A. The BCA shall review equipment performance prior to warranty expiration (performed by the 10-month point of 12-month warranties) to accomplish the following minimum items.
   1. Identify items that need correcting under warranty prior to expiration.
   2. Identify and remedy operational problems.
   3. Conduct a Lessons Learned meeting regarding problem encountered during the commissioning process.

## 11.9 Final Commissioning Report

A. The BCA shall complete and submit a Final Commissioning Report at the end of the commissioning process.
   1. One (1) electronic copy and three (3) hard copies.

# SECTION 12

# COMPANY INTERFACE

12.1 Project Contacts

12.2 Kick- off Meeting

A. A Kick-Off meeting will be held following award of lease agreement. Representatives of the Developer, A-E firm, and Company shall attend the meeting. This meeting does not replace the pre-construction meeting.

B. Discuss the dates for design review submittals, including any partial submittal dates. Based on this discussion, dates will be established for CFC document sign-off and a pre-construction meeting.

12.3 Documents

C. General
1. The minimum documents are listed in Table 12-1, Design Document Submittal Schedule. Other documents may be listed in the body of this design criteria.
2. Drawings, specifications, and calculations shall be sealed by the responsible Professional Engineer or Architect registered in the State of Tennessee.
3. Text documents shall be provided electronically in MS Word format, unless otherwise indicated.
4. Room Data Sheets shall be provided by the Company electronically in PDF and MS Excel format.

D. Drawings
1. Drawings shall include all dimensional plans, elevations, sections, details, notes, and identification of materials and equipment necessary to complete construction of project. Existing drawings shall be appropriately revised to cross reference changes incorporated by this design and shall be included with CFC drawings.
2. CFC drawings shall be reviewed and initialed by all the A-E design disciplines in every drawing's squad-check block to signify that interfaces are correct, interferences do not exist and overall coordination of design has taken place.
3. Drawing shall be produced using electronic software compatible with Bentley MicroStation format.
4. The minimum drawing scale, unless otherwise approved in writing by the Company, shall be as follows:
   a. 1/8" = 1'-0" for plans
   b. 1/4" = 1'-0" for building sections
   c. 1/2" = 1'-0" for detail sections
   d. 1" = 20'-0" for site plans

5. Indicate north to the top of the drawing sheet except where site conditions dictate otherwise.
6. A vicinity map shall be required, locating the facility relative to major highways and interstate access to the site. Key Plans shall be provided as appropriate.
7. Drawings shall be "E" size (34" x 44") with standard Company title block (Company to provide electronic border file). Company will provide guidance on filling out title block to ensure finished drawings will go directly into Company's electronic storage system without modifications.
8. Drawing numbers will be provided by the Company.
9. Compatibility with Company's electronic storage and indexing system shall be tested prior to schematic or Title I design review. A representative electronic set of project drawings from each discipline shall be provided for compatibility. The Company will provide guidance for correction of any problems encountered. Problems shall be corrected by the A-E and resubmitted to the Company in two weeks.
10. Electronic master seed file provided by the Company.

E. Construction Specifications

**1.** Construction specifications shall be provided that specify material, size, type, & schedule to be installed including all installation requirements when implemented to meet Design Requirements & Standards.

2. During Title II, design development and contract document phases, the Company will generate Division 1 - General Requirements and Division 18 – Welding. These Divisions shall be included in the final contract document package.
3. CFC Construction Specifications shall be provided in PDF and MS Word format.
4. Each Division's index sheet shall be signed and stamped by the responsible registered engineer or architect.

F. Engineering Standards

1. Engineering standards used shall be referenced and included along with the CFC Construction Specifications.

G. Calculations

1. Design calculations shall clearly document design decisions, assumptions, and basis for the design (codes, standards, design loads, design factors, etc.). Design calculations shall be checked and signed by a qualified engineer for accuracy and concurrence with design assumptions and philosophy.
   a. Calculations shall be stamped by the responsible registered profession engineer or architect.
2. Calculations shall be provided in hard copy and electronically in PDF format.

H. Design Basis Document

1. Prepare a Design Basis Document, DBD, providing the programmatic detail to describe systems, subsystems and major components, identify relevant codes and standards. Provide a cost benefit analyses as an attachment to the DBD. The DBD shall contain P&ID's, One-line diagrams, floor loadings, Room Data Sheets, and system descriptions at a minimum.
2. The DBD shall be organized using the Uniformat II per ASTM Uniformat II E1557 in MS Word format at 30% and 99% review.

I. Control Points and As-built Requirements
   1. A minimum of two survey control points with their coordinate values and elevations shall be shown on the design drawings.
   2. Design coordinates and elevations shall be determined for utilities, roads, and parking areas at their principal points of definition. This information shall be provided on the design drawings.
      a. The principal points of definition for utility systems shall include utility poles, obstructions, manholes, valves boxes, and crossings with other systems.
      b. Principal points of definition for potable water and natural gas distribution systems shall be valve boxes, main line intersects, and fire hydrants.
   3. Design documents shall require the Developer (contractor) to maintain red line as-built drawings during the construction and submit upon completion of project.
      a. Developer shall submit as-built coordinates and elevations of the underground utilities as soon as they are available.
      b. Electronic Record drawings will be created from the red line as-built drawings by the Developer.
         1) Record drawings shall be in Microstation format.
         2) Record drawings provided by the A-E or Developer shall be stamped by the registered professional engineer or architect.

J. Excavation and Penetration Permits
   1. Provide Engineering any excavation and penetration permits that will be required for construction in accordance with Local / State requirements.
   2. Completed Excavation and Penetration Permits shall be provided to the Company in PDF format.

K. Miscellaneous Design Documents
   1. See Table 12-1, Design Document Submittal Schedule, and discipline sections for more information.
   2. Miscellaneous design documents shall be provided in hard copy and MS Word format, unless other electronic format is approved.

12.4 Design Review

L. Formal design reviews with the Company shall be held at the following as a minimum:
   1. Title I (schematic design phase) 30% complete
   2. Title II (design development phase) 60% complete
   3. Title II (contract documents, pre CFC) 99% complete

M. Company will return comments to Developer within 15 days of receipt of submittal packages.

N. The Developers A-E shall provide formal written responses to the Company's design review comments 10 days after receipt of Company comments.

O. All design reviews shall be held at ORNL unless otherwise agreed by the Company. All disciplines shall attend the design reviews.

P. Before issuing CFC documents, the A/E shall resolve written comments received during the preliminary and final reviews. Comments that deviate from standard industry practices shall not

be implemented unless mutually agreed upon in writing by the Developer and the Company's Project Engineer.

12.5 Design Document Submittals

Q. Identify submittal information with contract number, project title, A-E's name, and date submitted.

R. See Table 12-1, Design Document Submittal Schedule, for a limited summary of submittal information at each design phase. The A-E shall verify submittals as identified throughout the document.

S. For each submittal provide eight (8) hard copies and two (2) electronic copies.

T. At CFC submittal, provide one additional unbound hard copy of construction specifications, in 8 ½" x 11" format.

U. Shop drawings including final A-E comments shall be submitted to Company for information only.

V. Specific Submittals
1. Construction Specification
a. Title I 30% submittal shall only include the index of proposed Construction Specifications.
b. Title II 60% submittal shall be an edited version of the Construction Specification with all edits highlighted using MS Work Track Changes or similar.
c. Title II 99% submittal shall have all 60% comments incorporated and 60% highlights removed. The 99% submittal shall represent a complete design except for any final comments as a result of ORNL review of 99% package. Therefore the only items to complete between 99% submittal and CFC are the incorporation of final Company comments.

Table 12-1
Design Document Submittal Schedule

| DISCIPLINE | REVIEW | | | |
|---|---|---|---|---|
| | 30% | 60% | 99% | CFC |
| 1. MULTI-DISCIPLINE: | | | | All work |
| | | | | |
| | | | | |
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| | | | | |
| | | | | |
| Value Engineering Study | X | | | |
| ASHRAE 90.1-1999 Compliance Documentation | X | | | |

| Table 12-1<br>Design Document Submittal Schedule | | | | |
|---|---|---|---|---|
| DISCIPLINE | REVIEW | | | |
| | 30% | 60% | 99% | CFC |
| Excavation/Penetration Permit | | X | X | |
| Formal written responses to design review comments | X | X | X | |
| Construction Specification – Provide index only at 30% | X | X | X | |
| Design Basis Document | X | | X | |
| | | | | |
| 2. CIVIL: | | | | All work |
| Site Access Plan - Index drawing & notes | | X | X | |
| Geotechnical Report (if required) | X | | | |
| Access Road Improvements & Additions Plans and Details | X | X | X | |
| Site utilities Plan and Details | X | X | X | |
| Site Grading Plan | X | X | X | |
| Storm Drain - Plans and details and Profiles | X | X | X | |
| Calculations (including 500 yr hydrologic evaluation) | X | X | X | |
| Project Specific SWPPP | | X | X | |
| | | | | |

| Table 12-1 continued<br>Design Document Submittal Schedule | | | | |
|---|---|---|---|---|
| DISCIPLINE | REVIEW | | | |
| | 30% | 60% | 99% | CFC |
| 3. STRUCTURAL: | | | | All work |
| Framing - Plans & Elevations | X | X | X | |
| Framing - Sections and details | | X | X | |
| Foundations – Plans | X | X | X | |
| Foundations - Sections and details | | X | X | |
| Miscellaneous - Plans, sections and details | | X | X | |
| Calculations | X | X | X | |
| | | | | |
| 4. ARCHITECTURAL: | | | | All work |
| PART 2 - Finish Board/Mock up | | PART | PART 4 | |
| Floor Plans | X | X | X | |
| Roof Plan | | X | X | |
| Exterior Elevations | X | X | X | |
| Wall Sections | | X | X | |
| Partial Plans | X | X | X | |
| Reflected Ceiling Plan | | X | X | |
| Miscellaneous Schedules (Door, Room Finish, etc.) | | X | X | |
| Miscellaneous Plans and Details | | X | X | |
| Calculations | | X | X | |
| | | | | |
| 5. MECHANICAL – HVAC: | | | | All work |
| Plans | X | X | X | |
| Elevations, Sections and Details | | X | X | |
| Equipment Schedules | X | X | X | |
| Controls Diagrams/P&ID's/Sequence of Operations | X | X | X | |
| Calculations | | X | X | |
| See MULTI-DISCIPLINE items for additional requirements. | | | | |
| | | | | |
| 6. MECHANICAL - PIPING: | | | | All work |
| Building Systems Plans | X | X | X | |
| Site Utility Systems Plans & Details | X | X | X | |
| Isometrics | | X | X | |
| Systems Details | | X | X | |
| Schedules | X | X | X | |
| Control diagrams/P&IDs/Sequence of Operations | X | X | X | |
| Calculations | | X | X | |
| Equipment Specifications | | X | X | |
| | | | | |

| Table 12-1 continued<br>Design Document Submittal Schedule | | | | |
|---|---|---|---|---|
| DISCIPLINE | REVIEW | | | |
| | 30% | 60% | 99% | CFC |
| 7. FIRE PROTECTION: | | | | All work |
| Code Footprint | X | X | X | |
| Fire Protection Systems | X | X | X | |
| Fire Alarm Plan | | X | X | |
| Fire Alarm Wiring and Riser Diagrams | | X | X | |
| Compliance Review | X | X | X | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| 8. ELECTRICAL: | | | | All work |
| Electrical Site Plan, Legend, and Notes | X | X | X | |
| One Line Diagram | X | X | X | |
| Panel Schedules | | X | X | |
| Building Power and Receptacle Plan | | X | X | |
| Grounding Plan | | X | X | |
| Duct Bank Details | | X | X | |
| Conduit and Cable Schedules | | X | X | |
| Schematics, Interconnection, and Wiring Diagrams | | X | X | |
| Miscellaneous Details, Sections, and Elevations | | X | X | |
| PLC Interconnection Wiring Diagram | | X | X | |
| Instrument Loop Diagrams | | X | X | |
| Process & Instrument Diagram | | X | X | |
| | | | | |
| 9. COMMUNICATION | | | | All work |
| Communication Plan | | X | X | |
| | | | | |
| 10. SECURITY | | | | All work |
| Security Plan | | X | X | |
| | | | | |
| PART 5 - 11. COMMISSIONING | | | | All work |
| Commissioning Plan | | X | X | |
| | | | | |
| | | | | |

END OF SECTION 12 - COMPANY INTERFACE

## Table 1: Space Program Summary

| Room # | Room Name | Quantity | Min. Floor Area | Total NUSF |
|---|---|---|---|---|
| **Laboratories** | | | | |
| 1.1 | Wet Chemistry Lab | 1 | 660 sf | 660 |
| 1.2 | Quality Control Lab | 1 | 660 sf | 660 |
| | | | **Subtotal** | **1,320** |
| **Specialty Rooms** | | | | |
| 2.1 | Semi-Production Room | 1 | TBD | TBD |
| 2.2 | Production Line Control Room | 1 | 500 sf | 500 |
| 2.3 | Motor Control Center (MCC) | 1 | 2,640 sf | 2,640 |
| 2.4 | Packaging and Storage | 1 | 500 sf | 500 |
| 2.5 | Locker Rooms/Showers | 2 | 250 sf | TBD |
| | | | **Subtotal** | **TBD** |
| **Office** | | | | |
| 3.1 | Offices | 4 | 150 sf | 600 sf |
| 3.2 | Entry Lobby | 1 | 120 sf | 120 sf |
| 3.3 | Conference Room | 1 | 280 sf | 280 sf |
| 3.4 | Small File Storage and Fax Room | 1 | 80 sf | 80 sf |
| 3.5 | Small Copy Room | 1 | 80 sf | 80 sf |
| 3.6 | Break Area | 1 | 180 sf | 180 sf |
| | | | **Subtotal** | **1,340 sf** |
| **Support** | | | | |
| 4.1 | Building Telecom. Room (provided for building telecom system) | 1 | 120 sf | 120 sf |
| 4.2 | Building Mechanical Room | 1 | As Req'd | TBD |
| 4.3 | Janitors Room | 1 | 40 sf | 40 sf |
| 4.4 | Guest Restroom (unisex, accessible) | 1 | 60 sf | 60 sf |
| 4.5 | Employee Restrooms | 1 | As Req'd | TBD |
| | | | **Subtotal** | **TBD** |

**Room Name:** Wet Chemistry Lab
**Room Number:** 1.1

| **General Information** | | | | | |
|---|---|---|---|---|---|
| Room Name: | Wet Chemistry Lab | Number of Occupants: | | Quantity of room type: | 1 |
| Function | Mixing room for chemicals used for surface treatment and sizing carbon fiber tow. | Hours per Day | 8 | Minimum floor area: | 660 sf |
| | | Days of the week: | 5 | Min. Room Dimension | |
| | | Primary Adjacencies | Production line - Surface Treatment Process | | |
| | | Secondary Adjacencies | | | |

Additional comments:

It is recommended that the lab design be based on a standard panning module of 10'-6" x 31'-6". This room will require emergency eyewash and shower stations to comply with OSHA. Provide a 3' x 8' curbed mixing area with spill collection. The curbed area shall have a minimum capacity of 70 gallons. A floor drain is not required in the curbed area, a portable pump will be used for disposal of spilled material.

| **Construction and Finishes** | | | |
|---|---|---|---|
| Wall Material: | Gypsum Board or CMU | Minimum Ceiling Height: | 10 ' |
| Wall Finish: | Paint | Ceiling Material: | Open to Structure |
| Floor Finish: | Sealed Concrete (see finish comments) | Door(s) Material: | As determined by Developer |
| Wall Base: | Rubber | Specialty Doors: | NA |
| Windows: | Alum. frame window system | Window Treatment: | Blinds on exterior windows |

Finish Comments:

Paint shall be high durability industrial grade water based epoxy (low VOC) to provide chemical resistant, washable surface. The floor of the mixing area shall have a chemical resistant and sealer impervious to liquids.

Construction Comments:

| **Casework** | | | | |
|---|---|---|---|---|
| Casework Description/Item: | Countertop Use | Counter Hgt. | Special requirements | GFE |
| 16 lf laboratory base cabinets with countertop w/ lab sink | Chemical preparation | 36" adjustable | 30" Deep | Yes |
| 16 lf laboratory wall and base cabinets | Chemical preparation | 36" adjustable | 30" Deep | Yes |
| Nano Capable Hood (8' wide) | NA | NA | None | Yes |
| 5 - 30" x 60" movable lab tables-grouped to form an island | Chemical preparation | 36" adjustable | None | Yes |

Casework Comments:

All laboratory casework in this room shall be provided and installed by the Company. Final hook-up for plumbing electrical, HVAC or other services are by the Developer The Developers A/E shall coordinate with the Company to ensure that all necessary rough-ins for data, power, plumbing, HVAC and other services are included in the construction documents.

| **Furniture and Furnishings** | | | | |
|---|---|---|---|---|
| Furniture and Furnishings List: | Exist/New | Quantity | Exist. Location | GFE |
| | | | | |
| | | | | |
| | | | | |

Furniture and Furnishing Comments:

## Equipment

| Sizing Mix Lab Equipment List: | Exist/New | location | qty | length | width | height | weight | GFE |
|---|---|---|---|---|---|---|---|---|
| 8' Wide Fume Hood (Nano Capable) | New | NA | 1 | TBD | 8'-0" | TBD | TBD | Yes |
| Stainless Steel Mixer 10 hp, 4 speed | New | NA | 1 | TBD | | TBD | TBD | Yes |
| Scale | New | NA | 1 | TBD | | TBD | TBD | Yes |
| Stainless Steel Sizing Tank elevated with drain outlet to bath | New | NA | 1 | TBD | | TBD | TBD | Yes |
| | | | | | | | | |
| | | | | | | | | |
| Electrolyte Mix Lab Equipment List: | | | | | | | | |
| Stainless Steel Electrolyte mixing tank | New | NA | 1 | TBD | | TBD | TBD | Yes |
| Stainless Steel Electrolyte storage tank | New | NA | 1 | TBD | | TBD | TBD | Yes |
| Pump for transfer | New | NA | 1 | TBD | | TBD | TBD | Yes |
| Platform to access tanks | New | NA | 1 | TBD | | TBD | TBD | Yes |
| Stainless Steel tank heaters, bayonet, electric | New | NA | 1 | TBD | | TBD | TBD | Yes |
| Stainless Steel agitator, bayonet, electric | New | NA | 1 | TBD | | TBD | TBD | Yes |
| Instrumentation flow meters | New | NA | 1 | TBD | | TBD | TBD | Yes |
| Electrolyte handling system | New | NA | 1 | TBD | | TBD | TBD | Yes |
| | | | | | | | | |
| | | | | | | | | |

Equipment Comments:

Equipment shall be provided and installed by the Company, Final electrical, HVAC and other service hookups are by the respective subcontractor of The Developer.

## HVAC

| | | | |
|---|---|---|---|
| Relative Humidity: | Range is 30%-55% | HVAC Reliability: | No Redundancy |
| Directional Airflow: | | Heat Generating Equip.: | |

HVAC Comments:

Temperature limits are 68°F – 80°F, Fume hood exhaust must be filtered (HEPA), fume hood, space temperature, and pressurization control system to be interfaced with the Building Automation System (BAS).

## Electrical

| Circuit | Location | Qty | Notes: |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

Electrical Comments

Lighting - 40 fc.
Telecomm Outlets - 1 wall mounted voice, 1 bench top voice, data every 8 ft (6 minimum).

## Hazards

| Hazards List | Hazard Type (health, physical, corrosive etc.) | Containment req'd |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |

Hazards Comments

Chemicals used in the Wet Chemistry Lab are as follows: Ammonium bicarbonate or sodium hydroxide-20 cu ft. @ 20 % max, epoxy emulsion-20 cu ft. @ 20% max, silicon emulsion-15 cu ft. @20% max, graphite nanomaterials-10 liters-solid @100%

**Room Name:** Quality Control Lab
**Room Number:** 1.2

| **General Information** | | | | | |
|---|---|---|---|---|---|
| Room Name: | Quality Control Lab | Number of Occupants: | | Quantity of room type: | 1 |
| Function | Lab space for testing and evaluating carbon fiber. | Hours per Day | 8 | Minimum floor area: | 660 sf |
| | | Days of the week: | M-F | Min. Room Dimension | TBD |
| | | Primary Adjacencies | | | |
| | | Secondary Adjacencies | | | |

Additional comments:

It is recommended that the lab design be based on a standard panning module of 10'-6" x 31'-6". Provide a 3' x 8' area for tow testing equipment adjacent to the 22 lf of base and wall cabinets.

| **Construction and Finishes** | | | |
|---|---|---|---|
| Wall Material: | Gypsum Board or CMU | Minimum Ceiling Height: | 10'-0" |
| Wall Finish: | Paint | Ceiling Material: | Open to Structure |
| Floor Finish: | VCT (anti static) | Door(s) Material: | As determined by Developer |
| Wall Base: | Rubber | Specialty Doors: | NA |
| Windows: | Alum. frame window system | Window Treatment: | Blinds on exterior windows |

Finish Comments:

Paint shall be high durability industrial grade water based epoxy (low VOC) to provide washable surface.

Construction Comments:

| **Casework** | | | | |
|---|---|---|---|---|
| Casework Description/Item: | Countertop Use | Counter Hgt. | Special requirements | GFE |
| 30 lf laboratory base cabinets with countertop w/ lab sink | Chemical preparation | 36" adjustable | 30" Deep | Yes |
| 22 lf laboratory base and wall cabinets | Chemical preparation | 36" adjustable | 30" Deep | Yes |
| 5 - 30" x 60" movable lab tables-grouped to form an island | Chemical preparation | 36" adjustable | None | Yes |
| | | | | |

Casework Comments:

All laboratory casework in this room shall be provided and installed by the company. Final hook-up for plumbing electrical, HVAC or other services are by the seller The A/E shall coordinate with the company to ensure that all necessary rough-ins for data, power, plumbing, HVAC and other services are included in the construction documents.

| **Furniture and Furnishings** | | | | |
|---|---|---|---|---|
| Furniture and Furnishings List: | Exist/New | Quantity | Exist. Location | GFE |
| | | | | |
| | | | | |
| | | | | |

Furniture and Furnishing Comments:

**Equipment**

| Equipment List: | Exist/New | location | qty | length | width | height | weight | GFE |
|---|---|---|---|---|---|---|---|---|
| Tow testing equipment | New | | TBD | TBD | TBD | TBD | TBD | Yes |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

Equipment Comments:

Equipment shall be provided and installed by The Company, Final electrical, HVAC and other service hookups are by the respective subcontractor of The Seller. Additional equipment to that listed above will be required and shall be coordinated by the Seller with the Company during design

**HVAC**

| | | | |
|---|---|---|---|
| Relative Humidity: | Range is 30%-55% | HVAC Reliability: | no redundancy |
| Directional Airflow: | | Heat Generating Equip.: | |

HVAC Comments:

Temperature limits are 68°F – 80°F, Fume hood exhaust must be filtered (HEPA), fume hood, space temperature, and pressurization control system to be interfaced with the Building Automation System (BAS).

**Electrical**

| Circuit | Location | Qty | Notes: |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

Electrical Comments

Lighting - 50 fc. Task lighting under cabinets installed over benches.
Telecomm Outlets - 1 wall mounted voice, 1 bench top voice, data every 6 ft (8 minimum).

**Hazards**

| Hazards List | Hazard Type (health, physical, corrosive etc.) | Containment req'd |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

Hazards Comments

**Room Name:** Semi-Production Room
**Room Number:** 2.1

**General**

| | | | | | |
|---|---|---|---|---|---|
| Room Name: | Semi-Production Room | Number of Occupants: | TBD | Quantity of room type: | 1 |
| Function | Production room for Carbon Fiber manufacturing line. | Hours per Day | 8 | Minimum floor area: | TBD |
| | | Days of the week: | M-F | Min. Room Dimension | TBD |
| | | Primary Adjacencies | Wet Chemistry Lab | | |
| | | Secondary Adjacencies | Storage Room, Locker Rooms | | |

Additional comments:

Prox card access is required at all entry points for this room. This room will contain the Carbon Fiber Semi-production Line and Melt Spin Precursor Line equipment used in the manufacture of carbon fiber. The production line will require a clear floor area 400' x 72' with a clear height of 32'-0". This area shall be a no-fly zone equipped with a crane that cannot be obstructed by the building structure, utilities, or equipment. The hook height of the cane shall be 32'-0". The no-fly zone is sized to allow for future installation of an "Advanced Technology Line". At the developers option, it is acceptable to construct a second level in areas of the high bay not restricted by the no-fly zone contingent on meeting all space requirements defined in this design criteria, and the approval of the Company. This room will require emergency eyewash and shower stations to comply with OSHA.

**Construction and Finishes**

| | | | |
|---|---|---|---|
| Wall Material: | TBD | Minimum Ceiling Height: | 32'-0" (Crane Hook Height) |
| Wall Finish: | TBD | Ceiling Material: | Open to Structure |
| Floor Finish: | Sealed Concrete | Door(s) Material: | As determined by Developer |
| Wall Base: | None required | Specialty Doors: | Overhead Coiling Door 18'x16' |
| Windows: | Clerestory for day-lighting | Window Treatment: | As determined by Developer |

Finish Comments:

The finishes selected for this room shall meet the durability standards required in a commercial industrial facility.

Construction Comments:

Provide drainage trench and cover the full length of the CFSL at the center of the no-fly zone as defined in Section 6 - Piping. Floor slab shall slope to the trench drain 1/4"/ft minimum. Provide clerestory windows the full length of the production line for day lighting. The sill of all windows in this area shall be no less the 14'-0" above finish grade, roof, or any other exterior horizontal surface below the windows. Interior and exterior windows will be one way glass to prevent visual access into the production room.

**Casework**

| Casework Description/Item: | Countertop Use | Counter Hgt. | Special requirements | GFE |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Casework Comments:

**Furniture and Furnishings**

| Furniture and Furnishings List: | Exist/New | Quantity | Exist. Location | GFE |
|---|---|---|---|---|
| | | | | |
| | | | | |

Furniture and Furnishing Comments:

**Equipment**

| Equipment List: | Exist/New | location | qty | length | width | height | weight | GFE |
|---|---|---|---|---|---|---|---|---|
| Bridge Crane | New | | 1 | 400' | 72' | 32' | 10 Ton | No |
| Carbon Fiber Semi-Production Line (CFSL) Equip: | | | | | | | | |
| Spooled precursor creel | New | | | TBD | TBD | TBD | TBD | Yes |
| Baled Precursor Feed Station ( Creel and Feed Frame) | New | | | TBD | TBD | TBD | TBD | Yes |
| Pretreatment System | New | | | TBD | TBD | TBD | TBD | Yes |
| Tension Stands | New | | | TBD | TBD | TBD | TBD | Yes |
| Tow Oxidation Ovens | New | | | TBD | TBD | TBD | TBD | Yes |
| Bulk Materials Oxidation Oven | New | | | TBD | TBD | TBD | TBD | Yes |
| Low Temperature Carbonization Furnace | New | | | TBD | TBD | TBD | TBD | Yes |
| High Temperature Carbonization Furnace | New | | | TBD | TBD | TBD | TBD | Yes |
| Fiber Spreading System | New | | | TBD | TBD | TBD | TBD | Yes |
| Surface Treatment Station (washing & drying) | New | | | TBD | TBD | TBD | TBD | Yes |
| Size Application Stand | New | | | TBD | TBD | TBD | TBD | Yes |
| Take-up & Winding Station | New | | | TBD | TBD | TBD | TBD | Yes |
| Bulk Packaging Station | New | | | TBD | TBD | TBD | TBD | Yes |
| Thermal Oxidizer (TOX) | New | | | TBD | TBD | TBD | TBD | Yes |
| Regenerative Thermal Oxidizer (RTO) | New | | | TBD | TBD | TBD | TBD | Yes |
| Melt Spin Production Line (MSPL) Equipment | New | | | TBD | TBD | TBD | TBD | Yes |
| Future - Advanced Technology Line | New | | | TBD | TBD | TBD | TBD | Yes |
| | | | | | | | | |

Equipment Comments:

Equipment for the production line will be provided and installed a by the Company. The Semi-production line equipment listed is based on preliminary system information and are to be considered the minimum requirements. Additional equipment may be required. The detailed equipment specifications and requirements shall be confirmed with the Company prior to completion of the building design. The Seller shall coordinate with the customer during the design process to ensure that all necessary exhaust/ventilation systems, rough-ins for data/power and other services are included in the construction documents. Refer to Section 3 - Structural of the design criteria for crane requirements. The TOX and RTO shall be located outside the building and are noted for information only, they are part of the CFSL exhaust system.

**HVAC**

| | | | |
|---|---|---|---|
| Relative Humidity: | range is 30% - 55% | HVAC Reliability: | No Redundancy |
| Directional Airflow: | | Heat Generating Equip.: | |

HVAC Comments:

Nominal ventilation rate is 7.5 air changes/hour. The space temperature limits are 50°F – 113°F. Separate supply and exhaust fan systems are required. Roughing pre-filters on the supply and exhaust fan systems . Space Heaters are required to maintain the minimum space temperature.

**Electrical**

| Circuit | Location | Qty | Notes: |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

Electrical Comments

Lighting - 40 fc.
Telecomm Outlets - 4 wall mounted voice, 10 data.

**Hazards**

| Hazards List | Hazard Type (health, physical, corrosive etc.) | Containment req'd |
|---|---|---|
| | | |
| | | |

Hazards Comments

Chemicals used in the CFSL are as follows: Ammonium bicarbonate or sodium hydroxide-20 cu ft. @ 20 % max, epoxy emulsion-20 cu ft. @ 20% max, silicon emulsion-15 cu ft. @20% max, graphite nanomaterials-10 liters-solid @100%

**Room Name:** Production Line Control Room
**Room Number:** 2.2

| **General Information** | | | | | |
|---|---|---|---|---|---|
| Room Name: | Production Line Control Room | Number of Occupants: | TBD | Quantity of room type: | 1 |
| Function | This room will house control and monitoring systems for the production equipment | Hours per Day | 8 | Minimum floor area: | 500 sf |
| | | Days of the week: | M-F | Min. Room Dimension | 16 ' |
| | | Primary Adjacencies | Production Line & MCC | | |
| | | Secondary Adjacencies | | | |

Additional comments:

This room shall extend length wise centered on the production line. An air-lock vestibule will be required to protect sensitive electrical equipment form air-borne carbon fibers entering from the production area.

| **Construction and Finishes** | | | |
|---|---|---|---|
| Wall Material: | Gypsum Board or CMU | Minimum Ceiling Height: 14' | |
| Wall Finish: | Paint | Ceiling Material: | ACT |
| Floor Finish: | VCT (anti static) | Door(s) Material: | As determined by Developer |
| Wall Base: | Rubber | Specialty Doors: | NA |
| Windows: | Interior-HM frames w/ one way glass | Window Treatment: | As determined by Developer |

Finish Comments:

Construction Comments:

Exterior windows are not allowed for this room. Interior view panels are required for visual monitoring of the production line. All view panels shall be glazed with one way glass to prevent visual access form the outside the room.

| **Casework** | | | | |
|---|---|---|---|---|
| Casework Description/Item: | Countertop Use | Counter Hgt. | Special requirements | GFE |
| Work Surface to accommodate 2 work stations | | | | No |
| | | | | |
| | | | | |
| | | | | |

Casework Comments:

Minimum work surface for one station shall 5' long x 30"deep 30" above finish floor and shall include; a fixed pedestal type under counter 3 drawer file cabinet, and a 5 l.f. of lockable shelf space above the workstation. This casework is considered a minimum and can be expanded as determined by the developer.

| **Furniture and Furnishings** | | | | |
|---|---|---|---|---|
| Furniture and Furnishings List: | Exist/New | Quantity | Exist. Location | GFE |
| | | | | |
| | | | | |
| | | | | |

Furniture and Furnishing Comments:

**Equipment**

| Equipment List: | Exist/New | location | qty | length | width | height | weight | GFE |
|---|---|---|---|---|---|---|---|---|
| Equipment required to monitor semi-production line system | New | | TBD | TBD | TBD | TBD | TBD | Yes |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

Equipment Comments:

Equipment shall be provided and installed by the Company, Final electrical, HVAC and other service hookups are by the respective subcontractor of The Seller.

**HVAC**

| | | | |
|---|---|---|---|
| Relative Humidity: | Relative Humidity range is 30-55%. | HVAC Reliability: | No Redundancy |
| Directional Airflow: | | Heat Generating Equip.: | |

HVAC Comments:

The space temperature limits are 68°F – 80°F.

**Electrical**

| Circuit | Location | Qty | Notes: |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

Electrical Comments

Lighting - 40 fc., parabolic troffers.
Telecomm Outlets - 2 voice, 4 data.

**Hazards**

| Hazards List | Hazard Type (health, physical, corrosive etc.) | Containment req'd |
|---|---|---|
| | | |
| | | |

Hazards Comments

**Room Name:** Motor Control Center (MCC)
**Room Number:** 2.3

| **General Information** | | | | | |
|---|---|---|---|---|---|
| Room Name: | Motor Control Center (MCC) | Number of Occupants: | TBD | Quantity of room type: | 1 |
| Function | | Hours per Day | 8 | Minimum floor area: | 2,640 sf |
| | | Days of the week: | M-F | Min. Room Dimension | 16 ' |
| | | Primary Adjacencies | High Temperature Furnaces & Control Room | | |
| | | Secondary Adjacencies | | | |

Additional comments:

This room shall be accessible form the Semi-production Room. An air-lock vestibule will be required to protect sensitive electrical equipment form air-borne carbon fibers entering from the production area. The room shall be designed to be a close as feasible to the CFSL High temperature furnaces.

| **Construction and Finishes** | | | |
|---|---|---|---|
| Wall Material: | Gypsum Board or CMU | Minimum Ceiling Height: 14' | |
| Wall Finish: | Paint | Ceiling Material: | ACT |
| Floor Finish: | VCT (anti static) | Door(s) Material: | As determined by Developer |
| Wall Base: | Rubber | Specialty Doors: | NA |
| Windows: | Not required | Window Treatment: | NA |

Finish Comments:

Construction Comments:

| **Casework** | | | | |
|---|---|---|---|---|
| Casework Description/Item: | Countertop Use | Counter Hgt. | Special requirements | GFE |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Casework Comments:

| **Furniture** | | | | |
|---|---|---|---|---|
| Furniture and Furnishings List: | Exist/New | Quantity | Exist. Location | GFE |
| | | | | |
| | | | | |
| | | | | |

Furniture Comments:

**Equipment**

| Equipment List: | Exist/New | location | qty | length | width | height | weight | GFE |
|---|---|---|---|---|---|---|---|---|
| Motor Control Equipment | New | | TBD | TBD | TBD | TBD | TBD | Yes |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

Equipment Comments:

Equipment shall be provided and installed by the Company, Final electrical, HVAC and other service hookups are by the respective subcontractor of The Seller.

**HVAC**

| | | | |
|---|---|---|---|
| Relative Humidity: | Relative Humidity range is 30-55% | HVAC Reliability: | 100% redundant cooling is required. |
| Directional Airflow: | | Heat Generating Equip.: | |

HVAC Comments:

The space temperature limits are 68oF – 80oF.

**Electrical**

| Circuit | Location | Qty | Notes: |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

Electrical Comments

Lighting - 40 fc.
Telecomm Outlets - 4 wall mounted voice, 4 data (to serve electrical metering data acquisition).

**Hazards**

| Hazards List | Hazard Type (health, physical, corrosive etc.) | Containment req'd |
|---|---|---|
| | | |
| | | |

Hazards Comments

**Room Name:** Packaging and Storage
**Room Number:** 2.4

| **General Information** | | | | | |
|---|---|---|---|---|---|
| Room Name: | Packaging and Storage | Number of Occupants: | | Quantity of room type: | 1 |
| Function | Storage space for precursor and the carbon fiber tow produced in the facility, and preparation and packaging for shipping. | Hours per Day | | Minimum floor area: | 500 sf |
| | | Days of the week: | | Min. Room Dimension | 15 ' |
| | | Primary Adjacencies | Convenient to the Production Line | | |
| | | Secondary Adjacencies | | | |

Additional comments:

The room will be a secured (prox card access) cage. It is acceptable to include this in the high bay portion of the facility. The room will provide secured storage for baled precursor, spooled precursor, spooled carbon fiber and, dry bulk chemicals. Provide a floor area adequate for storing a minimum of eight 4' x 4' pallets of baled precursor with a mezzanine of equal or larger size above the baled precursor storage area. Provide a stair to comply with egress requirements for building occupants access to the mezzanine. The room shall be designed with adequate access and manuvering space for a fork truck to remove and place pallets on the mezzanine or floor. The mezzanine will be used to store spooled precursor, spooled carbon fiber and, dry bulk chemicals used in the Wet Chemistry Lab.

| **Construction and Finishes** | | | |
|---|---|---|---|
| Wall Material: | CMU where occurs | Minimum Ceiling Height: TBD | |
| Wall Finish: | Paint | Ceiling Material: | Open to Structure |
| Floor Finish: | Sealed Concrete | Door(s) Material: | NA |
| Wall Base: | None Required | Specialty Doors: | NA |
| Windows: | NA | Window Treatment: | NA |

Finish Comments:

Construction Comments:

This room is secured cage area.

**Casework**

| Casework Description/Item: | Countertop Use | Counter Hgt. | Special requirements | GFE |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Casework Comments:

**Furniture and Furnishings**

| Furniture and Furnishings List: | Exist/New | Quantity | Exist. Location | GFE |
|---|---|---|---|---|
| | | | | |
| | | | | |

Furniture and Furnishing Comments:

**Equipment**

| Equipment List: | Exist/New | location | qty | length | width | height | weight | GFE |
|---|---|---|---|---|---|---|---|---|
| Shrink Wrap equipment | New | NA | TBD | TBD | TBD | TBD | TBD | Yes |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

Equipment Comments:

Shrink Wrap equipment will be provided and installed by The Company. Final hook-up shall be by The Seller. The AE shall coordinate with The Customer to obtain rough-in information for the equipment and include the required information in the contract documents.

**HVAC**

| | |
|---|---|
| Relative Humidity: | HVAC Reliability: |
| Directional Airflow: | Heat Generating Equip.: |

HVAC Comments:

Ventilation and heating by production area ventilation and heating systems. The temperature limits are 50°F – 113°F.

Electrical

| Circuit | Location | Qty | Notes: |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

Electrical Comments

Lighting - 30 fc.
Telecomm Outlets - 1 wall mounted voice, 2 data.

**Hazards**

| Hazards List | Hazard Type (health, physical, corrosive etc.) | Containment req'd |
|---|---|---|
| Baled Precursor | Health - combustible material | No |
| | | |

Hazards Comments

Chemicals stored in the this area include the following: Ammonium bicarbonate or sodium hydroxide-four 50 lb bags, epoxy powder-four 50 lb bags, silicon powder-four 50 lb bags, 100lbs or more baled precursor (polyacrylonitrile - combustible material: see Section 7 - Fire Protection of the Design Criteria)

**Room Name:** Locker Rooms/Showers
**Room Number:** 2.5

| **General Information** | | | | | |
|---|---|---|---|---|---|
| Room Name: | Locker Rooms/Showers | Number of Occupants: | 10 | Quantity of room type: | 2 |
| Function | Male and Female locker rooms to accommodate 10 persons of each sex. | Hours per Day | NA | Minimum floor area: | TBD |
| | | Days of the week: | NA | Min. Room Dimension | As Req'd |
| | | Primary Adjacencies | Semi-Production Room and Building entry | | |
| | | Secondary Adjacencies | | | |

Additional comments:

Provide 2 female amd 2 male showers as part of the locker rooms. Provide adequate space for staff to change clothes in the locker rooms. Locker Rooms shall provide direct access to the respective male and female employee restrooms. Plan arrangement shall allow entrance to locker rooms without passing through the restrooms. Locker Rooms shall be convient to the Semi-poduction Room.

| **Construction and Finishes** | | | |
|---|---|---|---|
| Wall Material: | Gypsum Board or CMU | Minimum Ceiling Height: 10'-0" | |
| Wall Finish: | Paint | Ceiling Material: | Gypsum Board or ACT (with hold down clips) |
| Floor Finish: | Resilient Tile | Door(s) Material: | As determined by Developer |
| Wall Base: | Rubber | Specialty Doors: | NA |
| Windows: | NA | Window Treatment: | NA |

Finish Comments:

Although the locker rooms have direct access to the restrooms, the finishes indicated here do not apply to the restrooms. Refer to Section 4 of this Design Criteria for the Employee Restroom finishes.

Construction Comments:

| **Casework** | | | | |
|---|---|---|---|---|
| Casework Description/Item: | Countertop Use | Counter Hgt. | Special requirements | GFE |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Casework Comments:

| **Furniture and Furnishings** | | | | |
|---|---|---|---|---|
| Furniture and Furnishings List: | Exist/New | Quantity | Exist. Location | GFE |
| Minimum 6 ft. long bench | | | | No |
| | | | | |
| | | | | |

Furniture and Furnishing Comments:

**Equipment**

| Equipment List: | Exist/New | location | qty | length | width | height | weight | GFE |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

Equipment Comments:

**HVAC**

| | |
|---|---|
| Relative Humidity: | HVAC Reliability: |
| Directional Airflow: | Heat Generating Equip.: |

HVAC Comments:

**Electrical**

| Circuit | Location | Qty | Notes: |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

Electrical Comments
Lighting - 30 fc.

**Hazards**

| Hazards List | Hazard Type (health, physical, corrosive etc.) | Containment req'd |
|---|---|---|
| | | |
| | | |

Hazards Comments