Department of Energy

Portsmouth/Paducah Project Office
1017 Majestic Drive, Suite 200
Lexington, Kentucky 40513
(859) 219-4000

MAR 24 2014

PPPO-02-2190048-14

Mr. Todd Mullins
Federal Facility Agreement Manager
Division of Waste Management
Kentucky Department for Environmental Protection
200 Fair Oaks Lane, 2nd Floor
Frankfort, Kentucky 40601

Ms. Jennifer Tufts
Federal Facility Agreement Manager
U.S. Environmental Protection Agency, Region 4
61 Forsyth Street
Atlanta, Georgia 30303

Dear Mr. Mullins and Ms. Tufts:

TRANSMITTAL OF THE TREATABILITY STUDY DESIGN, DESIGN DRAWINGS AND TECHNICAL SPECIFICATIONS PACKAGE FOR THE C-400 INTERIM REMEDIAL ACTION PHASE IIB STEAM INJECTION TREATABILITY STUDY AT PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY, DOE/LX/07-1295&D1

Please find enclosed for your review is the certified *Treatability Study Design, Design Drawings and Technical Specifications Package for the C-400 Interim Remedial Action Phase IIb Steam Injection Treatability Study at Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-1295&D1. This design document, including drawings and specifications, describes the design and implementation of a treatability study for steam injection in the Regional Gravel Aquifer at C-400. The design is being transmitted for review in advance of Web-based review meetings.

If you have any questions or require additional information, please contact David Dollins at (270) 441-6819.

Sincerely,

Jennifer Woodard

Jennifer Woodard
Federal Facility Agreement Manager
Portsmouth/Paducah Project Office

Enclosure:
C-400 Treatability Study Design

e-copy w/enclosures:
brandy.mitchell@lataky.com, LATA/Kevil
brian.begley@ky.gov, KDEP/Frankfort
craig.jones@lataky.com, LATA/Kevil
darla.bowen@lataky.com, LATA/Kevil
dave.dollins@lex.doe.gov, PPPO/PAD
gaye.brewer@ky.gov, KDEP/PAD
kelly.layne@lataky.com, LATA/Kevil
kim.knerr@lex.doe.gov, PPPO/PAD
leo.williamson@ky.gov, KDEP/Frankfort
mark.duff@lataky.com, LATA/Kevil
michael.clark@lex.doe.gov, LATA/Kevil
mike.guffey@ky.gov, KDEP/Frankfort
myrna.redfield@lataky.com, LATA/Kevil
pad.dmc@swiftstaley.com, SST/Kevil
rachel.blumenfeld@lex.doe.gov, PPPO/PAD
reinhard.knerr@lex.doe.gov, PPPO/PAD
rob.seifert@lex.doe.gov, PPPO/PAD
stephaniec.brock@ky.gov, KYRHB/Frankfort
sunny.osborne@lataky.com, LATA/Kevil
todd.mullins@ky.gov, KDEP/Frankfort
tracey.duncan@lex.doe.gov, P2S/PAD
tufts.jennifer@epamail.epa.gov, EPA/Atlanta

CERTIFICATION

Document Identification: ***Treatability Study Design, Design Drawings and Technical Specifications Package for the C-400 Interim Remedial Action Phase IIb Steam Injection Treatability Study at Paducah Gaseous Diffusion Plant, Paducah, Kentucky,*** **DOE/LX/07-1295&D1**

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

LATA Environmental Services of Kentucky, LLC

Mark J. Duff, Paducah Project Manager — 3-24-14
Date Signed

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

U.S. Department of Energy (DOE)

Rachel H. Blumenfeld, Acting Site Lead
Portsmouth/Paducah Project Office — 3-24-14
Date Signed

DOE/LX/07-1295&D1
Primary Document

Treatability Study Design, Design Drawings and Technical Specifications Package for the C-400 Interim Remedial Action Phase IIb Steam Injection Treatability Study at Paducah Gaseous Diffusion Plant, Paducah, Kentucky

CLEARED FOR PUBLIC RELEASE

DOE/LX/07-1295&D1
Primary Document

Treatability Study Design, Design Drawings and Technical Specifications Package for the C-400 Interim Remedial Action Phase IIb Steam Injection Treatability Study at Paducah Gaseous Diffusion Plant, Paducah, Kentucky

Date Issued—March 2014

U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

Prepared by
LATA ENVIRONMENTAL SERVICES OF KENTUCKY, LLC
managing the
Environmental Remediation Activities at the
Paducah Gaseous Diffusion Plant
under contract DE-AC30-10CC40020

CLEARED FOR PUBLIC RELEASE

THIS PAGE INTENTIONALLY LEFT BLANK

CONTENTS

FIGURES

TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

ACRONYMS

2-D	two-dimensional
3-D	three-dimensional
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CSM	conceptual site model
DNAPL	dense nonaqueous-phase liquid
DOE	U.S. Department of Energy
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
ERH	electrical resistance heating
FFA	Federal Facility Agreement
IRA	interim remedial action
KDEP	Kentucky Department for Environmental Protection
PGDP	Paducah Gaseous Diffusion Plant
POE	point of exposure
QA	quality assurance
RAO	remedial action objective
RA	remedial action
RD	remedial design
RGA	Regional Gravel Aquifer
ROD	record of decision
SEE	Steam-Enhanced Extraction
TMP	temperature monitoring point
TSWP	treatability study work plan
UCRS	Upper Continental Recharge System
VOC	volatile organic compound

THIS PAGE INTENTIONALLY LEFT BLANK

EXECUTIVE SUMMARY

In April 2013, the U.S. Department of Energy, U.S. Environmental Protection Agency (EPA), and the Kentucky Department for Environmental Protection agreed to scope a treatability study for steam injection. The basis and approach for the steam injection treatability study is consistent with the guidance set forth in the EPA's *Guidance for Conducting Treatability Studies under CERCLA* (EPA 1992). Post-record of decision (ROD) or remedial design (RD)/remedial action (RA) treatability studies can provide the detailed design, cost, and performance data needed to optimize treatment processes and potentially to implement full-scale treatment systems. In the process of implementing a remedy, RD/RA treatability studies can be used (1) to select among multiple vendors and processes within a prescribed remedy (prequalification); (2) to implement the most appropriate of the remedies prescribed in a contingency ROD; or (3) to support preparation of detailed design specifications and the design of treatment trains. This study will provide data to assess the cost-effectiveness and feasibility of deploying steam injection with multiphase extraction at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant.

The planned treatability study will include the design, installation, and operation of one steam injection well location, with intermediate and deep screened intervals in the Regional Gravel Aquifer (RGA), together with a temperature monitoring array. The steam injection well will be installed to the base of the RGA (approximately 100 ft depth). The strategy for steam injection into the subsurface is controlled by hydrostratigraphic and thermal properties of the target formation.

The objective of the treatability study is to gather information on steam mobility in the RGA to inform the regulatory decision process for evaluating steam-enhanced remediation for Phase IIb. The treatability study is designed to observe the movement and distribution of steam using varying injection depths, rates, and pressures and provide data to refine the estimates of permeability, anisotropy/heterogeneity, and local groundwater velocity. The resulting information will be used to model steam injection and multiphase extraction (well spacing, locations, steam injection rates, and timing) to assess the technical implementability and cost-effectiveness of steam injection. Metrics to assess steam injection with multiphase extraction as a potential remediation technology have been developed as part of the treatability study design (see Section 6). Concurrence among the Federal Facility Agreement parties on key performance metrics will be established prior to finalizing this design.

The treatability study report will document the treatability study set up and operation, field data collection and results, steam injection modeling, and technology evaluation including technical implementability and cost.

THIS PAGE INTENTIONALLY LEFT BLANK

1. INTRODUCTION

The objective of this design report is to present the design basis, detailed design, operational strategy, and monitoring plan for the implementation of a treatability study to evaluate steam injection as a potential technology for the heating of the Regional Gravel Aquifer (RGA) in the Phase IIb treatment area of the C-400 Cleaning Building. The treatability study at the C-400 Building will be conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and will be consistent with the guidance set forth in the U.S. Environmental Protection Agency's (EPA's) *Guidance for Conducting Treatability Studies under CERCLA* (EPA 1992). The study will be consistent with the Federal Facility Agreement (FFA) as agreed to by the U.S. Department of Energy (DOE), EPA, and the Commonwealth of Kentucky (EPA 1998). The study will address the uncertainty regarding hydrogeological conditions in the middle and lower RGA and will facilitate an evaluation of the requirements for a full-scale implementation of steam injection throughout the RGA in the Phase IIb treatment area.

Background. The implementation of an interim remedial action (IRA) for the C-400 Cleaning Building as part of the *Record of Decision for Interim Remedial Action for the Groundwater Operable Unit for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (ROD) (DOE 2005) was initiated in December 2008. DOE completed Phase I of the IRA for the C-400 Cleaning Building in 2010 by implementing electrical resistance heating (ERH) to address VOC source mass in the Upper Continental Recharge System (UCRS) and the upper RGA in the east and southwest treatment areas. Phase IIa is in progress and consists of the implementation of ERH in the UCRS and upper RGA in the southeast treatment area. DOE evaluated attainment of remedial action objectives (RAOs) in mid-2011 for Phase I operations in the east and southwest treatment areas. The RAOs, as established in the C-400 ROD (DOE 2005), were as follows:

- Prevent exposure to contaminated groundwater by on-site industrial workers through institutional controls (e.g., excavation/penetration permit program);
- Reduce VOC contamination primarily trichloroethene (TCE) and its breakdown products in UCRS soil at the C-400 Cleaning Building area to minimize the migration of these contaminants to RGA groundwater and to off-site points of exposure (POEs); and
- Reduce the extent and mass of the VOC source (primarily TCE and its breakdown products) in the RGA in the C-400 Cleaning Building area to reduce the migration of the VOC contaminants to off-site POEs.

DOE's evaluation determined that the RAOs were met for the UCRS and upper RGA in the east and southwest treatment areas. A key performance objective of Phase I was to evaluate the heating performance of ERH throughout the vertical extent of the RGA in the southwest treatment area. A primary finding of Phase I in regard to this performance objective was that ERH was poorly matched to the RGA conditions in the vicinity of the C-400 Building as demonstrated by the inability of the Phase I ERH to reach target temperatures in the lower RGA.

In April 2013, DOE, EPA, and the Kentucky Department for Environmental Protection (KDEP) agreed to scope a treatability study for steam injection in the RGA in the southeast treatment area to understand the effectiveness of steam injection as a means of heating the RGA and the potential for full-scale use. During subsequent meetings in April, May, and June 2013, the FFA parties developed data quality objectives (DQOs) to help guide the development of the treatability study. This Treatability Study Design Report provides the design criteria and design details to guide the implementation of *The Treatability Study Work Plan for Steam Injection, Groundwater Operable Unit, at Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1294&D2 (TSWP) (DOE 2014).

2. TREATABILITY STUDY DESIGN BASIS

The design of the treatability study is based on the geologic and hydrogeologic site conditions and the conceptual site model (CSM) described in the TSWP. The key design basis components are summarized below. Details can be found in the referenced documents. The general site layout of the treatability study and the C-400 Building site conditions are shown on Figure 1. Details of the treatability study site layout are shown on Drawing C7DC40000A027, Appendix A.

2.1 GEOLOGY

In the immediate vicinity of Paducah Gaseous Diffusion Plant (PGDP), Coastal Plain deposits unconformably overlie Mississippian carbonate bedrock. In the central and northern part of the PGDP site, including the area of the C-400 Cleaning Building, the Coastal Plain sediments are composed exclusively of unconsolidated, interbedded, fine-grained sand, and silt and clay of the Upper Cretaceous-aged McNairy Formation. The thickness of the McNairy Formation at C-400 is approximately 250 ft.

A principal geologic feature in the PGDP area is the buried fore slope of the Porters Creek Clay Terrace, a subsurface boundary that trends approximately east to west across the southern portion of the plant. The fore slope of the Porters Creek Clay Terrace represents the southern limit of erosion or scouring of the ancestral Tennessee River. In the area north of the subsurface terrace fore slope, including the C-400 area, Continental Deposits directly overlie the McNairy Formation. Thicker sequences of Continental Deposits, as found underlying most of PGDP, represent valley fill deposits and can be divided informally into a lower unit (gravel facies) and an upper unit (silt facies).

The main hydrogeologic units in the C-400 area consist of the UCRS, the RGA, and the McNairy Formation. In the study area, the RGA and the first major sand of the upper McNairy Formation are separated by an approximately 9-ft thick lens of McNairy silts, sands, and clays, which act as an aquitard. Approximately 56 ft of silt and clay, with horizons of sand and gravel lenses, overlies the RGA. Soil boring SB59, sampled in April 2011, was used as the basis for the subsurface design and consists of the following (from top to bottom):

- Silt and sandy silt to a depth of 24.1 ft
- Sand and gravel units (2.0- to 4.6-ft thick), separated by fine sands and silts to a depth of 43.1 ft
- Silt to silty sand to a depth of 56.0 ft
- Very fine sand to a depth of 60.0 ft
- Sand and gravel to a depth of 95.6 ft
- Interbedded clay, sand, and silt to the total depth of the boring of 97.0 ft

The uppermost 24.1 ft of soils are disturbed soils and loess; the UCRS extends to a depth of 56.0 ft; and the RGA consists of the thick sequence of sand and gravel to a depth of 95.6 ft, the contact with the underlying McNairy Formation.

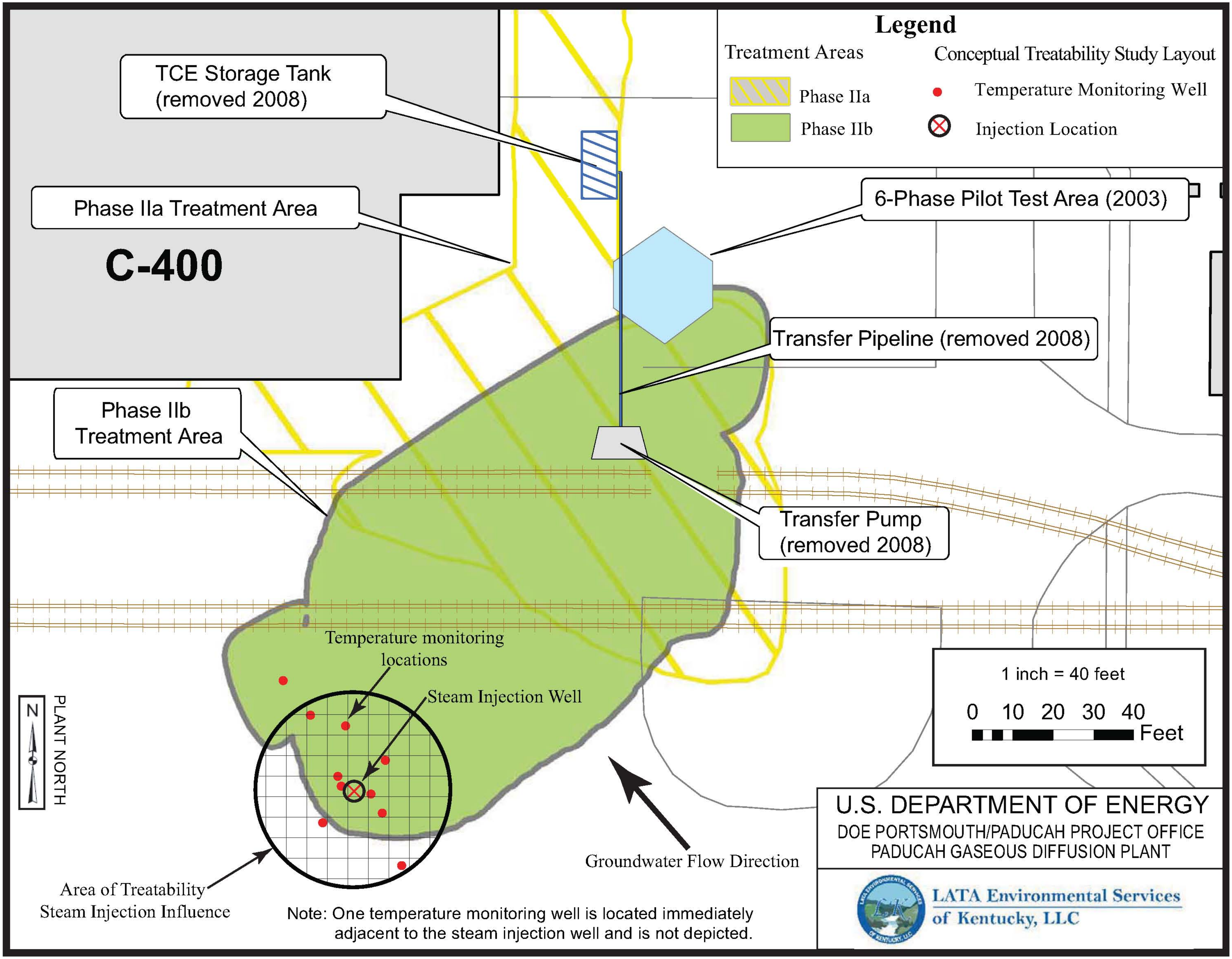


Figure 1. Map of C-400 Phase IIb Target Zone with Conceptual Layout of Treatability Study

2.2 HYDROGEOLOGY

In the area of C-400, the UCRS is mostly unsaturated. The RGA, the uppermost aquifer in the C-400 area, consists of the lowermost sand interval of the Upper Continental Deposits and the underlying sand and gravels to the top of the McNairy Formation. The RGA potentiometric surface is encountered at a depth of approximately 56 ft below ground surface. Groundwater flow in the RGA generally is to the north, eventually discharging into the Ohio River. Groundwater flow in the RGA in the C-400 area is generally to the northwest as part of the Northwest Plume, although some flow diverges to the east and to the west as part of the Northeast and Southwest Plumes, respectively.

Below the RGA is the McNairy Formation. The uppermost portion of the McNairy Formation typically contains a significant proportion of clay or silty clay. The hydraulic potential (water level) of the shallow McNairy Formation is slightly less than that of the RGA and dips northward, similar to the RGA. The clayey shallow McNairy functions as an aquitard restricting groundwater flow between the RGA and deeper McNairy Flow System.

Significant Properties. The RGA is the focus of the treatability study. Specific properties of the RGA that impact the treatability study include these:

- Permeability of the formation
- Vertical anisotropy
- Groundwater flow rate and direction

Spatial trends of the groundwater contaminant plumes, PGDP aquifer tests (Table 1), and groundwater flow model calibration values attest to significant variability in the hydraulic conductivity/permeability of the RGA. Results of the Phase I ERH action in the RGA (Southwest Treatment Area) indicate that the RGA hydraulic conductivity/permeability under the south end of C-400 is intermediate to high.

Table 1. Hydraulic Conductivity/Permeability (Lateral) Measurements

Test Area and Duration of Test	Hydraulic Conductivity as cm/sec (ft/day)/ Permeability as cm^2 (Darcy)	
	Low	**High**
C-404 Pumping Test (48 hours pumping)	1.87×10^{-2} (53)/ 1.91×10^{-7} (19.3)	3.77×10^{-2} (107)/ 3.84×10^{-7} (38.9)
C-537 Pumping Test (72 hours pumping)	3.53×10^{-2} (100)/ 3.60×10^{-7} (36.5)	5.29×10^{-2} (150)/ 5.39×10^{-7} (54.6)
Northeast Plume Containment Well Field Pumping Tests (46 to 123.5 hours pumping)	1.87×10^{-1} (529)/ 1.91×10^{-6} (193)	4.28×10^{-1} (1,213)/ 4.36×10^{-6} (442)
C-333 Pumping Test (72 hours pumping)	3.53×10^{-1} (1,000)/ 3.60×10^{-6} (365)	4.23×10^{-1} (1,200)/ 4.31×10^{-6} (437)
Northwest Plume North Containment Well Field Pumping Test (72 hours pumping)	9.50×10^{-1} (2,686)/ 9.68×10^{-6} (981)	2.01×10^{0} (5,700)/ 2.05×10^{-5} (2,080)

PGDP currently has no definitive assessment of the vertical anisotropy in the RGA. Lithological and electrical conductivity logs of the RGA under the southern portion of the C-400 area indicate little vertical variability; consequently, the vertical anisotropy may be low.

In general, publications of regional conditions indicate that groundwater flow in the RGA averages 1 to 3 ft/day, dependent on spatial variability of hydraulic conductivity/permeability and temporal variability in the hydraulic gradient. Principal controls on RGA hydraulic gradient are the amount and rate of leakage from PGDP utilities and the stage of the Ohio River, the primary discharge zone of the regional groundwater flow systems (RGA and McNairy). Commonly, the RGA hydraulic gradient in the area of PGDP ranges from a few ft vertical/1,000 ft lateral to a few ft vertical/10,000 ft lateral (10^{-3} ft/ft to 10^{4} ft/ft).

2.3 CONCEPTUAL SITE MODEL

The key features of the CSM, including geologic structure, at the south end of C-400 used as the basis for the treatability study design, are summarized below and shown in Figure 2. Details are found in the work plan (DOE 2014).

Key Site Characteristics. The following are the key characteristics of the C-400 CSM.

- The origin of the TCE in the subsurface is postulated to be from TCE pipeline leak(s) and spills at the loading point.

- The TCE release traveled vertically through the UCRS as dense nonaqueous-phase liquid (DNAPL) due to its density and the porous and permeable character of the construction backfill and near surface sediments in this area. When encountering a less permeable lens (e.g., silt), the DNAPL would travel laterally until encountering a discontinuity in that lens and then resume its downward migration.

- Over time, the DNAPL in the UCRS has continued to dissolve into the water phase with subsequent infiltration events (precipitation or plant line losses), resulting in dissolved-phase transport of TCE into the RGA.

- As the DNAPL has dispersed laterally in the finer grained sediments of the upper RGA, fine-grained zones have retained residual DNAPL.

- In the gravelly (more permeable) RGA, the DNAPL has been dispersed in the groundwater and transported vertically as DNAPL; some is present as residual DNAPL in the form of disconnected blobs and ganglia trapped by the capillary forces in the pore spaces (EPA 2009).

- If the DNAPL had sufficient mass for continuous interconnection, it continued traveling vertically through the permeable RGA until it reached a tighter matrix (i.e., McNairy) where it has pooled (McConnell and Numbered 1995).

- The current observed concentrations of TCE in the RGA likely result from a continuing release from the UCRS, from DNAPL pooled on capillary boundaries within the RGA, from discrete DNAPL ganglia, and from residual sorbed mass on the soil matrix.

Structural Controls on Contaminant Transport. Based on the concept that the DNAPL would travel vertically through a permeable geologic unit and then horizontally when encountering a tighter unit (clay

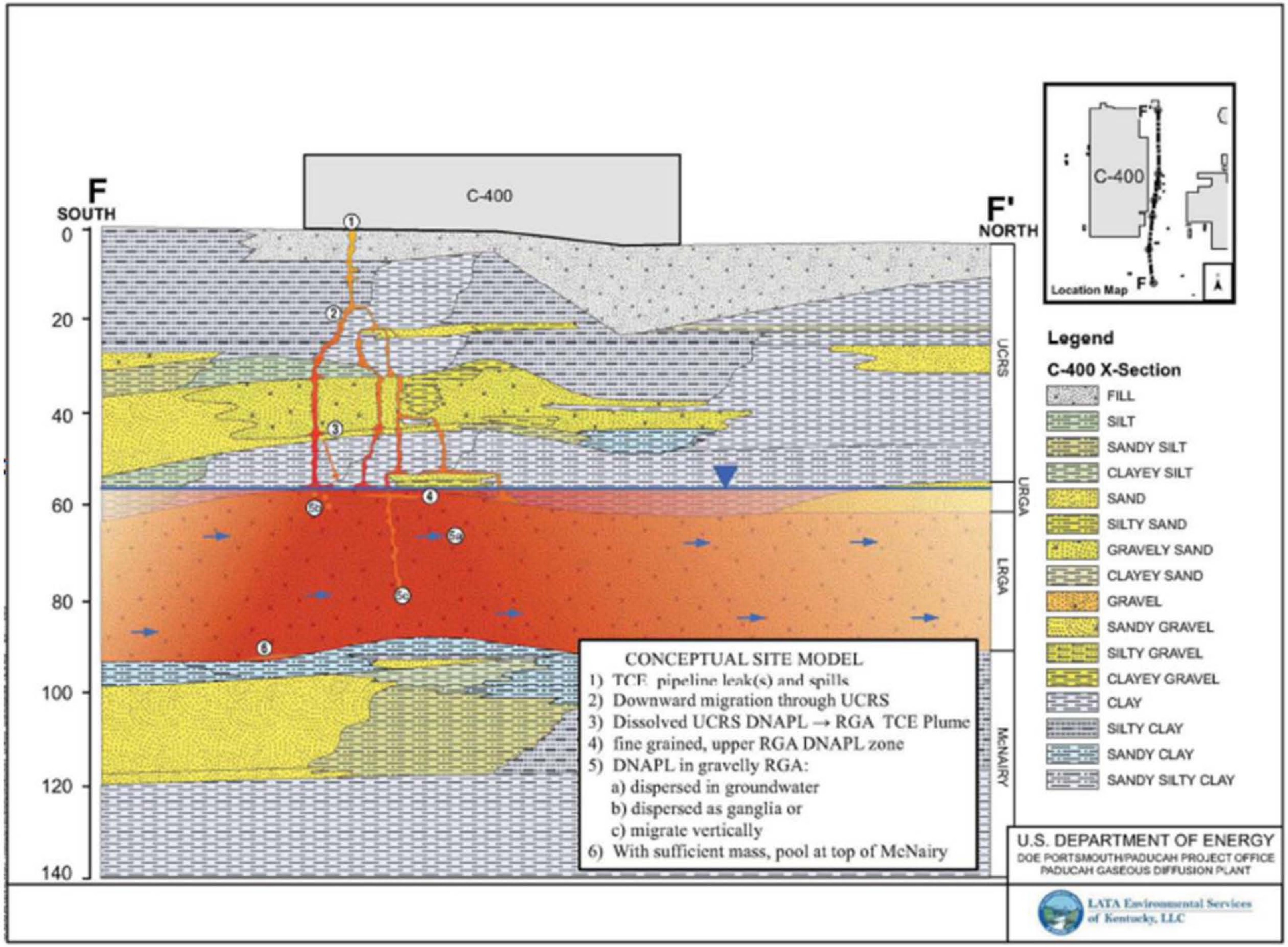


Figure 2. C-400 Conceptual Site Model Cross Section

or silt), it is important to refine the key hydrogeologic stratigraphy and structure that comprise the RGA and underlying McNairy Formation.

- RGA
    - Fine-grained upper sand layer of RGA, not laterally continuous
    - Dominant gravel aquifer
    - Base is defined by the upper erosional surface of the underlying McNairy Formation

- McNairy Formation: interbedded clay, sand, and silt, basal aquitard

The following are the key features of the stratigraphy of the treatability study area that impact soil heating.

- The layers within the RGA display variability in thickness and elevation.

- The upper sand is thin or absent in some areas, specifically directly below the pipeline loading point. The windows through a sand cap provide a direct conduit for the vertical migration of DNAPL from the UCRS into the RGA aquifer.

- The structural top of the McNairy is an erosional surface and displays scour and channel features.

2.4 INITIAL THERMAL MODEL RESULTS

A series of multiphase flow numerical simulations were performed to evaluate likely behavior of steam injection in the RGA at the C-400 Area of PGDP site in Kentucky (Falta 2013). The RGA is highly permeable, and it is bounded above and below by low permeability units. Steam-Enhanced Extraction (SEE) has been proposed as an alternative for remediation of the TCE contamination in the RGA at the C-400 Area. The background and results of the initial modeling are summarized below.

A Phase 1 effort to heat the RGA using ERH resulted in substantial heating of the top part of the RGA, but poor heating of the lower part of the RGA. The SEE method that currently is under consideration is a more aggressive approach, which, given the proper design, may be capable of treating the entire RGA. The key technical issue is whether steam injected during the SEE process will be effective in heating the entire thickness of the RGA and, in particular, the lower part of the RGA due to rapid buoyancy due to the low density of steam relative to groundwater. The tendency for rapid steam buoyancy to occur is proportional to the ratio of the steam injection rate to the permeability; low steam injection rates in high permeability systems are subject to strong steam buoyancy, while high steam injection rates in lower permeability systems exhibit less steam buoyancy. The horizontal and vertical permeability of the RGA in the C-400 area, as detailed in the TSWP, has not been measured, although pumping tests in the RGA at other locations on the Paducah site have indicated that the permeability is high, with horizontal hydraulic conductivities of hundreds to thousands of ft/day (Table 1).

The numerical simulations bound the range of hydrogeologic and operational conditions that reasonably could be expected during SEE in the RGA at Paducah. A total of 41 2-D and 3-D simulations were performed using steam injection rates of 1,000 to 5,000 lb/hour per well, with either one or two injection screen intervals per well location. The horizontal hydraulic conductivity varied from a minimum of 100 ft/day, to a maximum of 1,500 ft/day, and anisotropy ratio varied from a high of 20:1 to a low of 3:1. The simulations were performed using the DOE TOUGH2-TMVOC model, developed at the Lawrence

Berkeley National Laboratory. The TMVOC module is designed specifically for simulating the SEE process. The key findings, conclusions, and recommendations of the modeling are summarized below.

- Using an injection well spacing of about 40 ft, the simulations show that SEE with steam injection rates of 1,000 lb/hour per well may be effective in evenly heating the base of the RGA provided that the horizontal hydraulic conductivity is moderate (less than a few hundred ft/day) and the anisotropy ratio is high (10:1 or more). These simulations assumed a repeated five-spot pattern of injection and extraction wells with simultaneous operation of the wells.

- Substantial steam buoyancy was observed in cases with higher hydraulic conductivity and lower anisotropy ratios. In these cases, the injected steam was evenly distributed in much of the RGA, but did not migrate horizontally along the base of the RGA.

- With closer well spacing (30 ft), and higher steam injection rates (2,000 lb/hour per well), SEE may be capable of performing well with somewhat higher formation permeability and lower anisotropy ratios. This spacing and steam injection rate would most likely be considered to be an intensive application of SEE.

- The sensitivity of SEE design and performance in the RGA to the hydraulic conductivity and the anisotropy ratio highlights the need for further testing prior to full-scale field operations.

- The steam injection treatability study should be designed to collect data that can be used to estimate key parameters providing heating performance data that can be used in the evaluation of SEE as a viable technology for application for C-400 Phase IIb and to design of a full-scale SEE system (should SEE be found to be viable).

- The treatability study should evaluate steam injection into a single well, at one or two depths in the RGA, with varying steam injection rates.

- The subsurface temperature in the RGA should be measured at various distances and elevations throughout the test to monitor the change in temperatures and the arrival of the steam front horizontally and vertically in the subsurface.

- It is recommended that the numerical simulation part of the treatability study be conducted in three stages.

    — First, radially symmetric, 2-D radial, depth (r,z) simulations of the treatability study should be performed. These simulations would use the measured steam injection rates and known geometry and thermal properties as fixed input parameters and would use the RGA formation hydraulic conductivity and anisotropy ratio as calibration parameters. The key data to be matched during the model calibration process are the experimental temperature data measured in both space and time. It is possible or likely that a layered hydraulic conductivity structure may be required to reproduce the observed field temperature data. If the treatability study temperature data resulting from variable injection rates and pressures show strong asymmetry in the horizontal direction, it may be necessary to adopt a 3-D model design in order to match the field data.

    — The second modeling stage uses the hydraulic conductivity and anisotropy values from the calibrated treatability study model in a simple 3-D geometry. These simulations would be similar to the ones performed by Falta (Falta 2013) and could use ¼ of a repeated five spot pattern of injection and extraction wells. These simulations would provide a good indication of the likely performance of SEE on the interior part of a full-scale application and could be used to evaluate the effects of well spacing, steam injection rate, and vertical screen placement.

— The final modeling stage would extend the numerical model to a full 3-D field-scale size, with a model domain that extends somewhat beyond the full-scale treatment area. This model would include the effects of the groundwater hydraulic gradient and the full injection/extraction well pattern. This model would be used to evaluate the likely effects of groundwater flow on the SEE process, and it could be used in conjunction with the model from stage 2 to explore different SEE designs for full-scale implementation.

3. TREATABILITY STUDY PROCESS DESCRIPTION

SEE is the engineered combination of steam injection and vapor extraction for subsurface remediation. This technology significantly enhances the removal rate of volatile and semi-volatile source contaminants from the subsurface, both above and below the water table. One of the key factors that lead to the successful implementation of the SEE approach is the ability to use steam to uniformly heat the target source area. The source area heating process works as steam injected into the subsurface uniformly sweeps the target volume, mobilizing and volatilizing the contaminant present in all compartments—separate phase DNAPL, sorbed, and dissolved. As steam moves through the subsurface, it condenses and releases energy, heating the surrounding soil. Based on historical performance at sites contaminated with TCE, source areas that are heated to temperatures approaching the boiling point of water are treated effectively. The process is less effective for areas that do not achieve target temperatures. Thus, the distribution pattern of the steam and associated heat are important factors in understanding performance and designing a treatment system.

One of the benefits of steam injection is that the process can be implemented with standard, established engineering methods. Subsurface temperatures required for treatment of compounds such as TCE are easily attainable over broad treatment areas with standard equipment. Steam generated in boilers can be delivered through insulated steam piping or hoses pressure controlled and delivered to individual wellheads. Well placements are designed through thermal modeling using standard techniques from heat transfer, hydrogeological, and mass transport studies.

Because the use of heat to remove TCE and related contaminants from the subsurface has been demonstrated successfully at numerous locations, including in the UCRS at C-400 during a previous six-phase heating treatability study (DOE 2004) and during the Phase I remedial action, the effectiveness of steam injection with multiphase extraction in an appropriate geologic setting is not the primary concern of this treatability study. Instead, the effort will focus on refining and understanding the behavior of steam in the challenging hydrogeologic conditions in the RGA—a thick sand and gravel aquifer, with high permeability, low to moderate anisotropy, and moderate to high groundwater velocity.

Data collected during Phase I suggested that the buoyancy of the injected steam in this setting will impact the distribution of the steam and the ability to achieve target temperatures in the lower portions of the aquifer. The treatability study is intended to assess whether/how injected steam can heat the full thickness of the RGA, to the base of the RGA, to an effective distance from the injection wells, and to obtain data to support Phase IIb decisions.

The treatability study is designed to understand the behavior of steam when injected into the complex hydrogeology at the C-400 Building, specifically the RGA. Temperature monitoring locations will be constructed to cover the full thickness of the RGA and 2 ft into the overlying and underlying formations.

The treatability study injection and monitoring array will be constructed near the C-400 Building as shown on Drawing C7DC40000A027, Appendix A. Pretest soil samples will be collected, as described in Section 5, to document the formation characteristics in the vicinity of the treatability study array.

Eleven borings are planned for the study. One boring will be drilled to install the nested, shallow and deep steam injection wells and one temperature monitoring point (TMP). Ten borings are planned for installation of the temperature monitoring points. The injection and temperature monitoring wells are expected to be located such that they would be reusable if a full-scale implementation occurs.

3.1 STEAM INJECTION WELL

The vertical nested steam injection wells will be installed to evaluate the steam transport characteristics of the RGA below the UCRS. The location of the nested steam injection wells is shown on Drawing C7DC40000A027, Appendix A. These steam injection wells will consist of 3-inch-diameter carbon steel casings with stainless steel screens. Well details are shown on Drawing C7DC40000A028, Appendix A.

As part of the well installation, soil samples will be collected from the well boring and from selected temperature monitoring well borings for lithologic analysis. Several locations will be evaluated to determine the optimum number and location of the continuously sampled boreholes. The results of the lithologic examination of soil samples will be used to identify the presence of horizontal features that could affect steam injection flow and further define aquifer parameters.

3.2 WELL FIELD PIPING SYSTEM

A piping header for the steam system will be installed. Piping materials will be carbon steel (schedule 40, American Society for Testing and Materials (ASTM) B53 Grade B, electrical resistance welded or equivalent). The steam injection wells will be manifolded to the header by flexible steel hoses to establish flow to the wells. Appropriate controls, instrumentation, and valves will be provided to allow operation of individual injection wells or both wells simultaneously (Drawings P7DC40000A059 through P7DC40000A063, Appendix A).

3.3 STEAM INJECTION SYSTEM

A portable, electric steam boiler connected to the on-site water supply will deliver steam to each of the steam injection wells using a hard pipe manifold system and flexible braided hoses. Appropriate controls, instrumentation, and valves will be provided to allow operation of all wells individually and simultaneously. The steam injection system is capable of producing a maximum steam injection rate of approximately 6,000 lb/hour. The steam boiler will be operated so that injection rates can be increased incrementally based on the operational strategy. High pressure (greater than 10 bar) piping materials and braided flexible hoses for the steam process flows will be specified for high temperature service. The steam system will have a pressure control valve and by-pass loop, flow meter and appurtenances as the interface between the steam boiler plant and the steam injection-piping manifold. All piping and hose systems will be above ground and will rely on the flexible hoses and connections to accommodate thermal expansion.

3.4 TEMPERATURE MONITORING POINT

Monitoring is a critical component of the design for the treatability study. The monitoring design includes temperature-recording monitoring points for measuring subsurface thermal changes and steam migration. Robust monitoring is important because it provides a real-time understanding of the radius of influence in the subsurface. This allows detailed and timely adjustment of operational parameters to allow the tracking of the steam heating front during the varying treatability study injection scenarios. Based on experience at other steam injection sites and with a goal of minimizing potential data gaps due to temperature sensor failures, 11 TMPs will be installed as shown on Drawing C7DC40000A027, Appendix A. One TMP will be installed in the steam injection well boring and will be positioned against the borehole wall. This TMP will be used to determine if short circuiting within the gravel pack is occurring. Ten other TMPs will be installed in individual boreholes as shown on Drawing C7DC40000A027, Appendix A.

Each TMP will be comprised of approximately 16 temperature sensors that will be connected to a temperature data logger with a user-definable, data gathering capability of every 1 to 100 seconds. Twelve of the temperature sensors (depending on the thickness of the RGA) installed in each TMP will be spaced 3 ft apart within the RGA. Two temperature sensors at the bottom of the UCRS and two in the top of the McNairy Formation spaced 1 ft apart will give better definition of heat transfer characteristics into these formations that bound the RGA. The numbering of individual temperature sensors in each TMP will use the following nomenclature: TMP-xx-(yy), where TMP-xx is the individual TMP number and yy is the designation within the TMP. The nomenclature in each individual TMP will start with the temperature sensor that is positioned at the boundary between the top of the McNairy and the base of the RGA, which will be designated TMP-xx-(0). Distance above the McNairy/RGA boundary will be used for temperature sensors in the RGA and UCRS. The two temperature sensors in the McNairy will be designated by the distance below the McNairy/RGA boundary [TMP-xx(-1) and TMP-xx(-2)]. Temperature sensors located at elevations that correspond to the lower injection screen will be used to estimate the steam front migration in the lower RGA. During the Phase 1—Initial Steam Injection test, the temperature data from each sensor will be plotted as temperature versus sensor depth for each TMP location to track the steam front migration from the injection screen to each TMP location. Based on the results of Phase 1, Phase 2—Cool Down and any subsequent phases will be monitored in a similar manner.

A total of 176 temperature sensors will be installed in the treatability study implementation area. Of these, 160 will be located within a 20 ft radius of the steam injection wells. Given the vertical target zone that extends from 2 ft into the underlying McNairy to 2 ft into the overlying UCRS (40 ft), a volume of approximately 50,265 ft^3 will be monitored. This represents a temperature sensor density of 1 sensor per 314 ft^3 or 0.6% of the treatability study area. Based on past steam injection project experience, the worst case failure rate for a monitoring network of this size is approximately 5%, which represents less than 5% of the treatability study volume. This falls well within the margin of error associated with available thermal models and the calibration targets of 15% discussed below. The details of the temperature monitoring points are shown on Drawing C7DC40000A028, Appendix A.

3.5 INSTRUMENTATION AND MONITORING EQUIPMENT

Instrumentation and monitoring equipment is included in the system to monitor the treatability study progress and provide input of field conditions to the control system. The instrumentation includes temperature monitoring points for soil and groundwater temperature monitoring, and pressure, temperature, and flow monitoring of the steam injection system. Anticipated instrument parameters, as discussed below, provide the means by which system adjustments can be made.

Temperature of the subsurface may be monitored at each subsurface monitoring point. Resultant temperature(s) would indicate appropriate quantities of steam are being injected into the soil and at the appropriate location. The actual flow rate of steam to each injection well will be monitored with an energy transmitter.

The resulting steam flow and temperature data obtained will be used to evaluate flow of steam three dimensionally. Adjustments then may be made to the steam injection control system to permit control and evaluation of the soil heating process. The injection steam flow rates will be measured by energy transmitters ET100S and ET100D (P7DC40000A060, Appendix A) at each wellhead. Pressure reducing control valves PCV110S and PCV110D will control pressure of steam to each wellhead.

3.6 UTILITIES

Utilities required for operation of the steam injection system include:

- Electrical power (480 volt, 60 hertz, 3-phase) to power the stream boiler equipment;
- Electrical power (standard household voltage) for temperature monitoring equipment, programmable logic controller, and laptop computer; and
- Potable water feed for the boiler system.

Connection of the necessary utilities will be coordinated with the responsible PGDP personnel at the site. Contingency plans for service disruption will be coordinated through the treatability study project manager.

3.7 EVALUATION OF EXTRACTION WELL

In the TSWP, a downgradient extraction well was discussed as a component of the treatability study. During predesign scoping, the concept of a down-gradient extraction well was discussed further in regard to how such a well might be installed and operated as part of this treatability study. The conceptual basis and technical considerations for determining if an extraction well is a necessary component of the treatability study was discussed in detail by the design team. The following factors informed the team's decision to recommend that groundwater extraction well installation be removed from the scope of the treatability study. Appendix C provides additional details regarding this recommendation (ERM 2013).

- The steam injection treatability study is designed to collect data that can be used to estimate the horizontal and vertical hydraulic conductivities of the RGA and to provide heating performance data that can be used in the design of a full-scale SEE system. The treatability study involves steam injection into a single injection well, at two depths in the RGA, with varying steam injection rates. The subsurface temperature in the RGA will be measured at various distances and elevations throughout the test to show the arrival of the steam front. The rate of steam front migration is expected to be slowest at the base of the RGA and fastest near lithologic contrasts in the middle or upper RGA. The maximum radial extent of steam migration during this test will be limited to approximately 20 ft, as determined by the temperature monitoring system.

- It is well-established that TCE is removed effectively by SEE processes. In addition, a substantial amount of data was collected on groundwater and multiphase extraction under elevated temperature conditions during the Phase I ERH implementation. Accordingly a demonstration of contaminant removal is not required as part of the treatability study. The previously collected groundwater and multiphase extraction data will not contribute to the understanding of steam front movement. Given the treatability study objective of steam front understanding, the treatability study does not include groundwater or vapor extraction wells, and contaminants are not being removed as part of the test.

- The purpose of a downgradient groundwater extraction well would be to capture mobilized contaminants; however, due to the properties of TCE, the nature of the treatability study and the design team's experience at other similar sites, significant contaminant mobilization as a result of the study is not expected. As TCE or water containing TCE is heated, the TCE becomes more volatile and has an increasing tendency to partition into the vapor phase. The aqueous solubility of TCE, however, increases only modestly with increased temperature. The solubility of TCE recently was measured over a temperature range of 8°C to 75°C, and it was found that TCE solubility increased only by 23 percent over this considerable temperature range (Chen et al. 2012).

- A small degree of localized TCE redistribution may occur during the steam treatability study. As steam is injected, any TCE present in the steam zone will boil or volatilize and move toward the steam front where the steam vapor condenses back into liquid water. Because the treatability study implementation strategy calls for individual step tests at various flow rates, each test will be terminated when the steam front reaches a maximum distance of approximately 20 ft. Redistribution of contaminant phases, including both dissolved contaminant and DNAPL, would be limited nominally to this distance from the injection well. After the steam injection is stopped, the steam zone will cool and collapse back to a liquid water system.

- The treatability study is going to be performed within the volume that later will be treated by the full-scale TCE cleanup. The minor redistribution of TCE that might occur during the treatability study essentially would have no effect on the full-scale cleanup. Moreover, the entire TCE contamination source zone near the C-400 Building already is contained within the capture zone of the existing Northwest Plume extraction system.

THIS PAGE INTENTIONALLY LEFT BLANK

4. TREATABILITY STUDY OPERATIONAL STRATEGY

The steam injection treatability study is designed to allow for a high degree of flexibility in the steam injection strategy. Two co-located well screens, one near the bottom of the RGA (Lower RGA well screen), and one near the center of the RGA (Middle RGA well screen) allow for a number of possible injection configurations. The boiler that will be used in this study has purposefully been chosen to be capable of delivering variable steam flow rates up to 6,000 lb/hour total.

The treatability study implementation will be broken into four phases, similar to a groundwater pumping step test. The operation of the steam injection system during these four phases will be aimed at determining the response of the subsurface conditions as operational conditions are varied. A field-based iterative process will be employed to best evaluate these responses during the treatability study implementation. The four phases are described below.

4.1 PHASE 1—INITIAL STEAM INJECTION

The overall operational strategy begins with an initial steam injection test, using both Middle and Lower RGA well screens, with a steam injection rate of 500 lb/hour per screen (1,000 lb/hour total). This steam rate is consistent with the injection rate used in previous SEE applications. The two-screen configuration is a design that has received considerable attention in earlier discussions related to this study. Given the thickness of the RGA (~ 36 ft), using both injection locations allows steam to be introduced more uniformly across the RGA. In the event that strong layering or anisotropy is encountered, the two-screen configuration may provide better steam coverage in the RGA than a single screen configuration will provide.

The Phase 1 steam injection will continue for a maximum of 20 days, but will conclude in less than 20 days if steam temperatures of approximately 100°C[1] are reached before the end of the 20-day period at the lowest 3 RGA temperature sensors in temperature monitoring boring TMP-10 located 20 ft from the injection wells. The selection of a 20-day injection period is based on steam injection simulations by Falta (Falta 2013). Those simulations showed that for strongly anisotropic conditions (~ 20:1) with moderate hydraulic conductivity (100 ft/day), the steam front should reach a radial distance of about 15 ft in 10 days, if steam was injected at 500 lb/hour into both screens (Middle and Lower RGA).

If extreme steam rapid buoyancy develops, the condition where the anisotropy in the RGA is very low (~ 3:1) and the hydraulic conductivity is very high (1,000 ft/day), the Falta 2013 simulations indicated that the steam will migrate primarily in the vertical direction, leading to a very small steam zone at the base of the RGA, a moderately sized steam zone at the top of the RGA, and a large zone of hot water near the top of the RGA. For purposes of this treatability study, extreme steam rapid buoyancy is defined by rapid vertical movement of steam to the upper portions of the RGA and by the lack of observed steam temperatures at the lowest 3 thermocouples in the RGA (TMP-04-00, TMP-04-03, and TMP-04-06) located at a distance of 5 ft (TMP-04) from the injection well. The 20-day injection period is sufficient to determine whether extreme steam rapid buoyancy will occur. If extreme steam rapid buoyancy occurs, Phase 3 steam injection will not be conducted.

---

[1] Steam temperatures are defined as the boiling point of water at the target depth. Although the boiling point of water generally is defined as 100°C, variation in boiling point temperatures can occur due to changes in pressure at depth. Accordingly, references in this design document to steam temperatures or steam temperatures of approximately 100°C are intended to reflect the boiling point of water at target depth.

4.2 PHASE 2—INITIAL COOL DOWN

Following Phase 1, there will be a 7- to 14-day cool down period with no steam injection. The main purpose of this cool down period is to allow for an assessment of the data collected during Phase 1 and to allow for collapse of the steam zone. During this cool down period, the former steam zone will initially cool due to thermal conduction, buoyancy driven free convection of the hot water, and convection of the hot water due to the local groundwater flow. The first two cooling mechanisms are expected to be radially symmetric, but the cooling due to groundwater flow will lead to an asymmetry in the temperature pattern. If the groundwater pore velocity is greater than a few inches per day, then the asymmetry in the temperature response can be analyzed to assess the groundwater flow direction and velocity.

4.3 PHASE 3—STEAM INJECTION

Phase 3 steam injection will be conducted only if extreme steam rapid buoyancy does not occur during Phase 1 steam injection. The primary objective of Phase 3 is to evaluate lower RGA steam injection, as discussed below in Section 4.3.1. However, as discussed in Section 4.3.2 of this document, the treatability study might evaluate limited additional steam injection to address technical uncertainty.

4.3.1 Lower RGA Steam Injection

The Lower RGA steam injection test configuration will depend on the results of the Phase 1 test. There are two likely scenarios from the Phase 1 test that will be used to inform Lower RGA steam injection testing:

(1) If the Phase 1 test shows a relatively uniform steam front development with good contact at the base of the RGA, then steam will be injected during Phase 3 into the Lower RGA screen at a rate of 1,000 lb/hour for a maximum of 20 days. Steam injection during Phase 3 will conclude in less than 20 days if steam temperatures of approximately 100°C are reached before the end of the 20-day period at the lowest 3 RGA temperature sensors in temperature monitoring boring TMP-10 located 20 ft from the injection wells.

(2) If the Phase 1 test shows a moderate degree of steam rapid buoyancy, with some contact at the base of the RGA, then steam will be injected during Phase 3 into the Lower RGA screen at a rate of 2,000 lb/hour for a maximum of 10 days. Steam injection during Phase 3 will conclude in less than 10 days if steam temperatures of approximately 100°C are reached before the end of the 10-day period at the lowest 3 RGA temperature sensors in temperature monitoring boring TMP-10 located 20 ft from the injection wells.

4.3.2 Additional Steam Injection to Address Uncertainty

If the performance of the initial Phase 3 Lower RGA injection is comparable or only slightly better than the Phase 1 results in terms of observed vertical and horizontal temperature distribution and the measured rate of temperature increase (laterally) from the injection wells, then the treatability study implementation team could elect to conduct an additional steam injection activity using augmented injection rates and/or screen locations. This additional steam injection is intended to explore whether even higher steam flow rates in one or possibly both screens improves the performance of steam migration, as compared to Phase I and initial Phase 3 injections. If the follow-on steam injection test is determined to be necessary, then the test will involve increasing the steam injection rate in the bottom screen to 3,000 lb/hour and/or adding steam injection in the upper screen to a maximum rate of 3,000 lb/hour. In either case, the steam rate of steam front migration in the Lower RGA drops below 4 ft/day as measured from the steam front location at the completion of the initial Phase 3 Lower RGA injection.

4.4 PHASE 4—EXTENDED COOL DOWN

Following the Phase 3 steam injection, there will be a 30-day cool down period where temperature data are collected. If Phase 3 steam injection is not performed, then Phase 4 cool down will consist of an extension of the Phase 2 cool down period for a total cool down of 30 days. The main purpose of this extended cool down phase is to obtain information on temperature decay and the influence of groundwater flow through the zone of injection. Cooling, due to groundwater flow, will lead to an asymmetry in the temperature pattern. If the groundwater pore velocity is greater than a few inches per day, then the asymmetry in the temperature response can be analyzed to assess the groundwater flow direction and velocity. Treatability study demobilization will start at the beginning of this phase.

THIS PAGE INTENTIONALLY LEFT BLANK

5. TREATABILITY STUDY DATA COLLECTION AND MONITORING

5.1 INITIAL DATA COLLECTION

Limited soil sampling will be conducted during the installation of the injection wells. Continuous core sampling will be conducted in the steam injection well boring and in TMP borings TMP-9 and TMP-11. Geologic and photographic logs of each continuous core will be compiled by the field geologist. The cores will be observed closely to identify any changes in lithology. The soil descriptions will include the following:

- Grain size
- Sorting
- Grain shape (where applicable)
- Sedimentary and post depositional structures
- Consistency/density
- Moisture content

In addition, soil samples will be collected for grain size analyses [ASTM method D422-63(2007)] at 2-ft intervals throughout the depth of the RGA in the soil boring for the injection well to quantify changes in soil texture that could impact the vertical permeability and anisotropy/heterogeneity of the RGA.

5.2 SUBSURFACE TEMPERATURE SENSOR MONITORING

The 11 down-hole TMP arrays will begin collecting data prior to steam injection to establish background temperature profiles and will continue collecting data during steam injection and cool down phases of the study. Ten of the TMPs will be in dedicated boreholes, while one will be located against the borehole wall in the steam injection well boring. Temperature data will be captured by data loggers as described in Table 2.

5.3 STEAM SYSTEM MONITORING

To monitor the progress of the *in situ* steam injection treatability study, performance data will be collected by data loggers as described in Table 2. The following operating data will be collected electronically:

- Steam flow rate and pressure
- Temperature of the injected steam and the subsurface
- Steam boiler energy and water consumption

Pressure and flow rate monitoring of the steam line to each of the active wellheads will be via energy transmitters ET100S and ET100D. The actual working steam parameters to be injected will be determined at the daily operations meeting and will depend on the previous day's performance as well as that day's performance expectations. The actual daily change of steam parameters may be infrequent and will be dependent on the phase of the study (i.e., Phase 1, 2, 3, or 4).

Table 2. Metric Monitoring Program

Measurement Parameter	Location/Instrument	Data Frequency	Reading Frequency	Units	Accuracy	Repeatability/Completeness
Energy Transmitter ET 100D						
Fluid velocity	Downstream of HV-110D	Definable: 1 to 100 sec	Hourly during start up. Daily after.	ft/sec	± 1.0% of rate	± 0.1% of rate
Volumetric flow	Downstream of HV-110D	Definable: 1 to 100 sec	Hourly during start up. Daily after.	ft^3/sec	± 1.0% of rate	± 0.1% of rate
Temperature	Downstream of HV-110D	Definable: 1 to 100 sec	Hourly during start up. Daily after.	°F	± 2.0°F (± 1°C)	± 0.2°F (± 0.1°C)
Pressure	Downstream of HV-110D	Definable: 1 to 100 sec	Hourly during start up. Daily after.	PSIA	± 0.4% of full scale	± 0.05% of full scale
Mass flow	Downstream of HV-110D	Definable: 1 to 100 sec	Hourly during start up. Daily after.	lb/sec	± 1.5% of rate	± 0.2% of rate
Energy flow	Downstream of HV-110D	Definable: 1 to 100 sec	Hourly during start up. Daily after.	BTU/sec	± 1.5% of rate	± 0.2% of rate
Fluid density	Downstream of HV-110D	Definable: 1 to 100 sec	Hourly during start up. Daily after.	lb/ft^3	± 0.5% of rate	± 0.1% of rate
Fluid viscosity	Downstream of HV-110D	Definable: 1 to 100 sec	Hourly during start up. Daily after.	cP	± 0.5% of rate	± 0.1% of rate
Enthalpy	Downstream of HV-110D	Definable: 1 to 100 sec	Hourly during start up. Daily after.	BTU/lb	± 1.5% of rate	± 0.2% of rate
Energy Transmitter ET 100S						
Fluid velocity	Downstream of HV-110S	Definable: 1 to 100 sec	Hourly during start up for each Phase. Daily after.	ft/sec	± 1.0% of rate	± 0.1% of rate
Volumetric flow	Downstream of HV-110S	Definable: 1 to 100 sec	Hourly during start up for each Phase. Daily after.	ft^3/sec	± 1.0% of rate	± 0.1% of rate
Temperature	Downstream of HV-110S	Definable: 1 to 100 sec	Hourly during start up for each Phase. Daily after.	°F	± 2.0°F (± 1°C)	± 0.2°F (± 0.1°C)
Pressure	Downstream of HV-110S	Definable: 1 to 100 sec	Hourly during start up for each Phase. Daily after.	PSIA	± 0.4% of full scale	± 0.05% of full scale
Mass flow	Downstream of HV-110S	Definable: 1 to 100 sec	Hourly during start up for each Phase. Daily after.	lb/sec	± 1.5% of rate	± 0.2% of rate
Energy flow	Downstream of HV-110S	Definable: 1 to 100 sec	Hourly during start up for each Phase. Daily after.	BTU/sec	± 1.5% of rate	± 0.2% of rate
Fluid density	Downstream of HV-110S	Definable: 1 to 100 sec	Hourly during start up for each Phase. Daily after.	lb/ft^3	± 0.5% of rate	± 0.1% of rate
Fluid viscosity	Downstream of HV-110S	Definable: 1 to 100 sec	Hourly during start up for each Phase. Daily after.	cP	± 0.5% of rate	± 0.1% of rate
Enthalpy	Downstream of HV-110S	Definable: 1 to 100 sec	Hourly during start up for each Phase. Daily after.	BTU/lb	± 1.5% of rate	± 0.2% of rate
Other Operational Data						
Amperage	Energy Transmitter ET 01A	Definable: 1 to 100 sec	Hourly during start up for each Phase. Daily after.	Amp	± 1.0% of rate	± 0.1% of rate
Electrical Energy	Energy Transmitter ET 01B	Definable: 1 to 100 sec	Hourly during start up for each Phase. Daily after.	kW-hour	± 1.0% of rate	± 0.1% of rate

Table 2. Metric Monitoring Program (Continued)

Measurement Parameter	Location/Instrument	Data Frequency	Reading Frequency	Units	Accuracy	Repeatability/Completeness
Piping System Pressures	PG100 PG110D PG115D PG110S PG115S	Hourly during start up for each Phase. Daily after.	Hourly during start up for each Phase. Daily after.	PSIA	± 0.4% of full scale	± 0.05% of full scale
Temperature subsurface	TMP-01 TMP-02 TMP-03 TMP-04 TMP-05 TMP-06 TMP-07 TMP-08 TMP-09 TMP-10 TMP-11	Definable: 1 to 100 sec	Continuous during 1st hour and as migration rate dictates during start up for each Phase. Data stored hourly during start up, daily afterward.	°F	± 2.0°F (± 1°C)	75% of total temperature sensors
Consumable consumption water	Existing flow totalizer	Continuous	Weekly	gal	± 0.7% of rate	± 0.1% of rate

THIS PAGE INTENTIONALLY LEFT BLANK

6. TREATABILITY STUDY DATA EVALUATION

Metrics have been defined for guiding the data collection and subsequent evaluation as part of this treatability study. The metrics have been organized into four categories:

- Process metrics to assess RGA steam injection response (Section 6.2)
- Metrics for determining whether to conduct Phase 3 steam injection (Section 6.3)
- Metrics used to support modeling efforts for full-scale design (Sections 6.3–6.7)
- Metrics to determine full-scale steam injection cost and energy requirements (Section 6.8)

Concurrence among the FFA parties on key performance metrics will be established prior to finalizing this design.

6.1 DATA QUALITY OBJECTIVES

Table 2 in the TSWP presented the DQOs resulting from the collaborative effort between DOE Portsmouth/Paducah Project Office, EPA, and KDEP. The problem statement, "How will steam flow in the RGA in the southeast treatment zone?" formed the premise for DQO development. The primary data required will be engineering parameters associated with steam injection (flow rate, temperature, and pressure) and resulting temperature distribution in the subsurface. The quality objectives for these data are shown in Table 2, Metric Monitoring Program.

The results of the treatability study will be used to calibrate modeling simulations to support the subsequent assessment of technical implementability and cost-effectiveness.

6.2 PROCESS METRICS TO ASSESS RGA STEAM INJECTION RESPONSE

The treatability study will provide direct information on several key parameters and process metrics that can be used to assess the response to steam injection into the RGA, including the following:

- Operating data such as steam injection rates and corresponding injection pressures;

- Temperature data to compare the influence of a two-well screen injection configuration versus a single-well screen injection configuration; and

- Radial steam migration rates at various depths in the absence of interference from surrounding wells.

The specific metrics, including the accuracy, repeatability, and other factors, are described in Table 2.

6.3 METRIC FOR DETERMINING WHETHER TO CONDUCT PHASE 3 STEAM INJECTION

In the event extreme steam rapid buoyancy is indicated by the Phase 1 steam injection results, then Phase 3 steam injection will not be conducted. Extreme steam rapid buoyancy is defined by rapid vertical movement of steam to the upper portions of the RGA and by the lack of observed steam temperatures of approximately 100°C, at the lowest 3 thermocouples in the RGA at a distance of 5 ft (TMP-04) from the injection well.[2] This behavior would indicate that additional data collection, as part of this treatability study, would not be useful to assess the applicability of steam-enhanced remediation in the Lower RGA. The evaluation of Phase 1 results also will consider technical issues associated with steam delivery.

6.4 NUMERICAL MODEL REQUIREMENTS

I. The numerical model or models chosen to perform the mathematical analysis must have the following minimum capabilities in terms of physical process simulation:

- Capability for simulating transient compositional three-phase flow in a gas/aqueous/DNAPL system with full relative permeability and capillary pressure effects.
- Ability to model pressure-driven and density-driven flow in three dimensions in heterogeneous, anisotropic porous media with variable phase densities.
- Multiphase heat transfer and thermodynamics, including thermal conduction, latent and sensible heat convection, boiling, evaporation, and condensation.
- Capability to model multiple steam injection wells with variable injection rates and specific enthalpies.
- Capability to model multiple dual-phase extraction wells with specified well head pressure, and flowing gravity corrections for fluid pressures in the wellbore.

II. The selected numerical model must be publicly available, and extensively tested (results compared with other analytical and numerical solutions and field and experimental data). Specifically, the model must have the following characteristics:

- The model must be freely or commercially available to the public.
- The model must have been verified with analytical and other numerical solutions for problems involving multiphase flow and heat transfer in porous media. Documentation of this verification must be available, preferably from refereed journal publications; however, unpublished reports with accompanying verification data are acceptable.
- The model must have been validated with laboratory experiments and/or field applications of steam injection. Documentation of this validation must be available, preferably from refereed journal publications; however, unpublished reports with accompanying validation data are acceptable.
- Any modifications to the model source code must be disclosed, and results of testing must be provided to demonstrate that the model still performs as expected.

The simulation process will follow quality assurance (QA)/quality control documentation, consistent with industry standards for environmental/groundwater model documentation [e.g., ASTM D5718-13 (ASTM 2013); ASTM D5880-95 (ASTM 2006)]. As described in the TSWP, QA elements will address

---

[2] These observed conditions are comparable to simulation cases RZ-3, RZ-7, and RZ-9 in Falta 2013, where RGA horizontal hydraulic conductivity equals or exceeds 425 ft/day and anisotropy is 3:1.

software verification and validation; model development and intended use; description of the conceptual model; results of literature searches and other applicable background information; identification of model inputs; and discussion of boundary conditions, model limitations, and uncertainties. A description of the simulation process and attendant QA information will be prepared and provided as an appendix to the treatability study report.

6.5 NUMERICAL ANALYSIS OF THE TREATABILITY STUDY

Numerical analysis of the treatability study results from steam injection Phase 1 and Phase 3 (if conducted) and from cool down Phase 2 and 4 will include (1) analysis of Phase 1 steam injection efforts using a cylindrical, radially symmetric 2-D r-z numerical model; (2) analysis of the cool down Phase 2 and 4 using a 3-D model that includes the local groundwater flow; and (3) a 3-D model of the entire treatability study (i.e., Phases 1 and 2 if Phase 3 is not conducted or Phases 1, 2, 3, and 4), including all well geometries (one screen versus two screens) and steam injection rates tested. These are described in more detail below.

6.5.1 2-D Radially Symmetric Model of Phase 1 Steam Injection

It is anticipated that steam flows in the RGA during the initial steam injection period will be approximately symmetric around the injection well centerlines. This model will use a 2-D radial (r) and vertical (z) depth grid with appropriate layering to represent the UCRS, the RGA, and the McNairy confining unit, with fine discretization around the well screens and filter pack. The outer boundary of the model should be far enough away from the wells to avoid boundary effects (275 ft) (Falta 2013), and the model should extend from the ground surface, to a depth of 30 ft or more into the McNairy. The boundary at the ground surface should be atmospheric pressure and temperature. Estimates of the porous media thermal properties (rock grain density, porosity, rock grain specific heat capacity, and dry and wet thermal conductivity) consistent with the known properties of the RGA and geologic formations of similar composition (Lake 1989) should be used. The multiphase relative permeability and capillary pressure curves also should be consistent with the known properties of the RGA and geologic formations of similar composition (Looney and Falta 2000).

The model input will consist of the measured steam injection rates and specific enthalpies into the Middle and Lower RGA well screens. The model output will consist of the time-dependent, 2-D distribution of temperature; gas phase saturation; and pressure. The model will be calibrated by adjusting the RGA formation intrinsic permeability in the horizontal and vertical directions to produce a best match of the observed temperatures from the multiple temperature sensor locations. Matching the field data may require the use of layering within the RGA.

The primary calibration target is the steam arrival time at each temperature sensor, as determined by the time from the start of steam injection until steam temperatures of approximately 100°C are observed at the sensor. While there are no benchmarks for model calibration as there are with groundwater models, this approach was used successfully to calibrate modeling conducted as part of the 321M Area pilot testing at the Savannah River site. The model will be considered to be calibrated when it can predict the steam front arrival time to an accuracy of +/- 15% in at least 75% of the temperature sensors. Note that there will be approximately 160 individual temperature sensor locations in this test.

The key output from this calibration effort will be the values of horizontal and vertical permeability in the RGA in the vicinity of the Middle and Lower RGA well screens. It also is possible that information on the structure of layering in the RGA may be determined from this test.

6.5.2 3-D Analysis of Cool Down (Phases 2 and 4)

The results of the calibrated 2-D steam injection model will be used to construct a 3-D model of the same site, using the same vertical layering and horizontal and vertical permeability distribution. This model will be oriented with the expected direction of groundwater flow and will include a hydraulic gradient. The model then will be used to simulate the first steam injection experiment and the following cool down period. This model should match the steam injection results with accuracy similar to the radial model, but the focus is on modeling the temperature distributions during the cool down phase, especially any asymmetry that develops due to groundwater flow. The key adjustable parameter in this calibrated model will be the local hydraulic gradient and, to a lesser extent, the horizontal and vertical permeability. The results of this calibration are expected to be a determination of the actual groundwater velocity.

6.5.3 3-D Analysis of Entire Experiment

The final model of the treatability study builds on the first two calibration efforts, which will develop a model that uses the calibration criteria described in Sections 6.5.1 and 6.5.2, and continues the simulation beyond the cool down period to include any Phase 3 steam injection tests. The main purpose of this simulation is to refine further the models' ability to simulate the field scale behavior of injected steam. The model results will be evaluated using the calibration criteria developed in Sections 6.5.1 and 6.5.2 and will be compared to the observed temperature versus time results from the temperature sensors. Adjustments will be made until results are within the criteria, and a summary of differences between actual and modeled results will be prepared.

6.6 EXTRAPOLATION TO MULTIPLE WELL SCENARIOS

The next simulation step is to conduct small 3-D simulations of a symmetry element from a repeated pattern of steam injection and extraction wells.

The process of extrapolating previous modeling results to multiple well scenarios is described in some detail by Falta (Falta 2013), and it involves simulations of ¼ of a "five spot" injection/extraction setup. With this type of model, all of the sides have no-flow boundaries due to the interfering effects of surrounding wells. In other words, the symmetrical geometry of this type of model can be used to simulate the effect of having multiple surrounding wells, as would be expected in a full-scale deployment, without having to expand the model to explicitly include this larger number of wells. As before, the model extends from below the bottom of the RGA to the ground surface. The permeability distribution in this model will be taken from the results of calibration efforts described in Section 6.5, and the model will simulate simultaneous steam injection and dual-phase extraction from wells at the opposite corner of the domain. The well spacing, steam injection rates, and well screen locations will be varied to allow for a relatively rapid evaluation of expected field scale behavior on the inside part of a full-scale steam injection effort. These simulations will provide key information on the required well spacing and steam injection rates that will be needed in a full-scale design.

6.7 FULL-SCALE DESIGN CONCEPT DEVELOPMENT

The 3-D simulation of steam injection with multiphase extraction at C-400 will provide the basis for a conceptual full-scale design for deployment of the technology. Based on results of this modeling, a final well layout, incorporating optimal injection-extraction well spacing, will be designed. The importance of the well spacing is critical because it will help determine the operational period and heat requirements to ensure that steam reaches the bottom of the RGA across the entire target zone. Engineering specifications that will be derived from the 3-D simulation include the following:

- Number and placement of injection and extraction wells;
- Total energy requirements and resulting steam injection rates;
- Boiler requirements (including phasing of equipment to meet variable injection operations);
- Steam conveyance requirements (pipe/hose size, lengths);
- Vapor and groundwater extraction requirements;
- Vapor and groundwater treatment requirements;
- Extraction piping requirements; and
- Operational strategy (injection rates/pressures; injection time frames).

A 3-D model of steam injection with multiphase extraction deployment at C-400 also can be used during operations to gauge expected versus actual progress. This could include expected temperature distribution over time, compared with operational temperature monitoring, injection rates, and energy injected/extracted, as well as net expected versus actual injected energy during operations.

6.8 DETERMINATION OF FULL-SCALE STEAM INJECTION COST AND ENERGY REQUIREMENTS

As part of a full-scale design, an engineering cost estimate will be developed as the basis for determining the cost of using steam injection as part of a full-scale heating strategy during the CERCLA remedy evaluation and selection process. The cost estimate will include the number and placement of wells, the modeled flow estimations for injected steam and extracted fluids, the treatment costs required to meet the treatment goals for the volatilized and extracted mass, and the energy requirements for production of steam and operation of the treatment plant. The cost estimate will incorporate the expected operational time frame of the operations needed to achieve the RAOs as established in the C-400 ROD for a full-scale deployment of steam injection with multiphase extraction at C-400 (DOE 2005). The cost of waste disposal and decontamination and decommissioning also will be included.

Once the cost estimate has been completed, metrics including the cost per unit volume treated ($\$/yd^3$), the cost per unit volume of mass removed (\$/gallon) and/or treated, and the total cost will be determined based on the field results of the treatability study and the 3-D extrapolations to a full-scale deployment. This 3-D simulation of the full-scale steam injection scenarios can be compared to the theoretical energy (heat) requirements for full-scale remediation to provide an estimate of cost for the use of steam injection to meet the RAOs within the C-400 ROD (DOE 2005). The theoretical minimum energy requirement is the heat needed to raise the system conditions from ambient conditions (a temperature of about 15°C, and fully water saturated) up to the steam temperatures of approximately 100°C. This theoretical energy requirement is calculated easily from the RGA material properties (aquifer porosity, bulk density, specific heat capacity, water density and specific enthalpy) determined during the treatability study. This is the minimum amount of heat required because heat losses are not accounted for. The groundwater migration data from the treatability study will be introduced into the theoretical minimum energy estimate to get closer to actual heat loss conditions expected for a full-scale deployment.

For the RGA treatment volume determined by a full-scale design, the energy required divided by the volume gives the amount of energy required per unit volume (BTU/yd^3) of treated RGA material. This normalized energy requirement for a full-scale deployment then can be compared to results from other steam injection projects such as presented in the ESTCP summary document (Kingston et al. 2010) to the theoretical minimum energy requirement and to the metrics from the completion of Phase 1. This comparison can be used as one of the key metrics to determine the cost of deploying steam injection as a heating strategy for remediation of the RGA.

7. REFERENCES

ASTM (American Society for Testing and Materials) Standard D5880-95 2006. "Standard Guide for Subsurface Flow and Transport Modeling," ASTM International, West Conshohocken, PA, 2013 DOI: 10.1520/D5880-95R06, www.astm.org.

ASTM Standard D5718 2013. "Standard Guide for Documenting a Groundwater Flow Model Application," ASTM International, West Conshohocken, PA, 2013 DOI: 10.1520/D5718, www.astm.org.

Chen, F., D. L. Freedman, R. W. Falta, and L. C. Murdoch, 2012, "Henry's Law Constants of Chlorinated Solvents at Elevated Temperatures," *Chemosphere*, Vol. 86, No. 2, p. 156-165.

DOE (U.S. Department of Energy) 2004. *Final Report Six-Phase Heating Treatability Study at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2113&D2, U.S. Department of Energy, Paducah, KY, March.

DOE 2005. *Record of Decision for Interim Remedial Action for the Groundwater Operable Unit for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-2150&D2/R2, U.S. Department of Energy, Paducah, KY, July.

DOE 2014. *The Treatability Study Work Plan for Steam Injection, Groundwater Operable Unit, at Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1294&D2, U.S. Department of Energy, Paducah, KY, February.

EPA (U.S. Environmental Protection Agency) 1992. *Guidance for Conducting Treatability Studies under CERCLA*, Office of Solid Waste and Emergency Response (OSWER) Directive No. 9380.3-10, EPA/540/R-92/071a, U.S. Environmental Protection Agency, Washington, DC, October.

EPA 1998. *Federal Facility Agreement for the Paducah Gaseous Diffusion Plant*, U.S. Environmental Protection Agency, Atlanta, GA, February 13.

EPA 2009. *Assessment and Delineation of DNAPL Source Zones at Hazardous Waste Sites*, EPA/600/R-09/119, U.S. Environmental Protection Agency, Cincinnati, OH, September.

ERM (Environmental Resources Management) 2013. *Memorandum, Groundwater Extraction Well Requirement, Building C-400 Phase IIb Treatability Study, Paducah Gaseous Diffusion Plant, Paducah, KY,* Environmental Resources Management, Irvine, CA, November 12.

Falta, R. 2013. *Numerical Simulations of Steam Injection in the Regional Gravel Aquifer at the C-400 Area, Paducah Gaseous Diffusion Plant, Paducah, KY*, Falta Environmental, LLC, Clemson, SC, January 4.

Kingston Jennifer, Paul R. Dahlen, Paul C. Johnson, Eric Foote, and Shane Williams 2010. *Critical Evaluation of State-of-the-Art In Situ Thermal Treatment Technologies for DNAPL Source Zone Treatment*, ESTCP Project ER-0314, January.

Lake, L. W. 1989. *Enhanced Oil Recovery*, Prentice Hall, Englewood Cliffs, NJ.

Looney, B. B. and R. W. Falta 2000. *Vadose Zone Science and Technology Solutions*, Battelle Press, Columbus, OH, p. 1542.

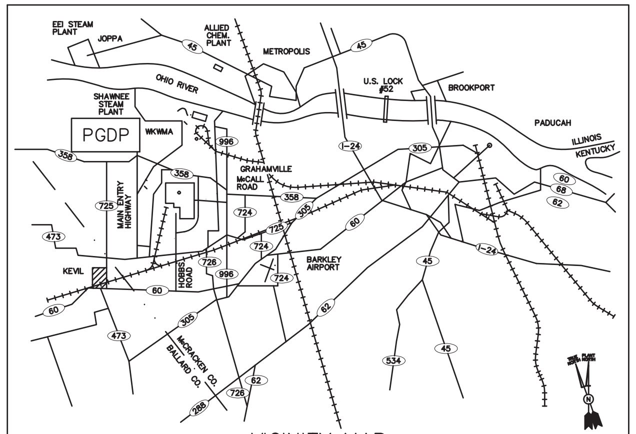
McConnell and Numbere 1995. *Final Report, Feasibility of Using Enhanced Recovery Techniques at the C-400 Site for DNAPL Removal*, Department of Geological Engineering and Petroleum Engineering, University of Missouri-Rolla, April.

APPENDIX A

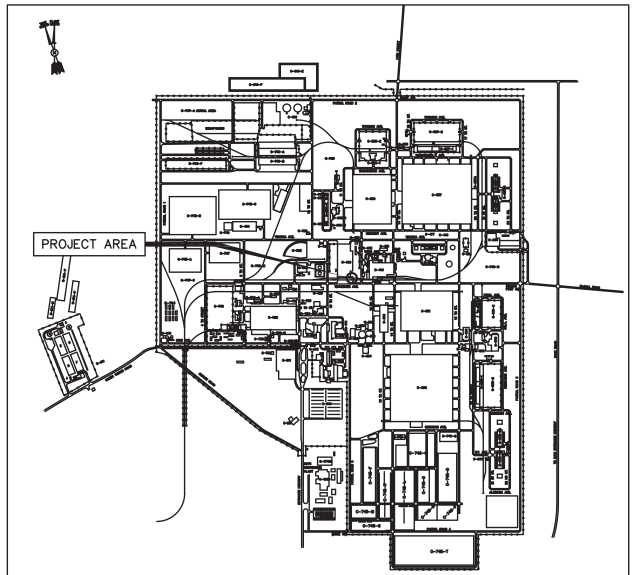
DRAWINGS

THIS PAGE INTENTIONALLY LEFT BLANK

DESIGN FOR C-400 STEAM INJECTION TREATABILITY STUDY



VICINITY MAP



PADUCAH GASEOUS DIFFUSION PLANT

DRAWING INDEX	
DWG NO.	TITLE
G7DC40000A001	COVER SHEET
C7DC40000A027	SITE PLAN
C7DC40000A028	STEAM INJECTION WELLS AND TEMPERATURE MONITORING POINTS
P7DC40000A058	SYMBOLS, IDENTIFICATION, ABBREVIATIONS, NOTES, AND REQUIREMENTS
P7DC40000A059	PROCESS FLOW DIAGRAM
P7DC40000A060	PIPING AND INSTRUMENTATION DIAGRAM (SHEET 1)
P7DC40000A061	PIPING AND INSTRUMENTATION DIAGRAM (SHEET 2)
P7DC40000A062	PIPING PLAN
P7DC40000A063	WELLHEAD AND PIPING DETAILS
E7DC40000A046	ELECTRICAL POWER ONE-LINE DIAGRAM
E7DC40000A047	ELECTRICAL POLE, TRANSFORMER, & PDP DETAILS
E7DC40000A048	LIGHTING DETAILS
E7DC40000A049	COMMUNICATIONS DIAGRAM

REV.	DATE	DESCRIPTION	DRAWN BY	DRAFT CHK	PROJ ENGR	LEAD ENGR	CONF CTRL/ NUCL SFTY	FAC MGR	EATS MGR
A	12/5/13	ISSUED FOR REVIEW	JE	JE	CRE	CRE			

DRAWING REVISIONS

LPE

DATE

PROFESSIONAL SEAL

U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

LATA Environmental Services of Kentucky, LLC
managed for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC30-10CC40020 Paducah, Kentucky

ERM
Environmental Resources Management
1218 3rd AVENUE, SEATTLE WASHINGTON
(425) 462-8591

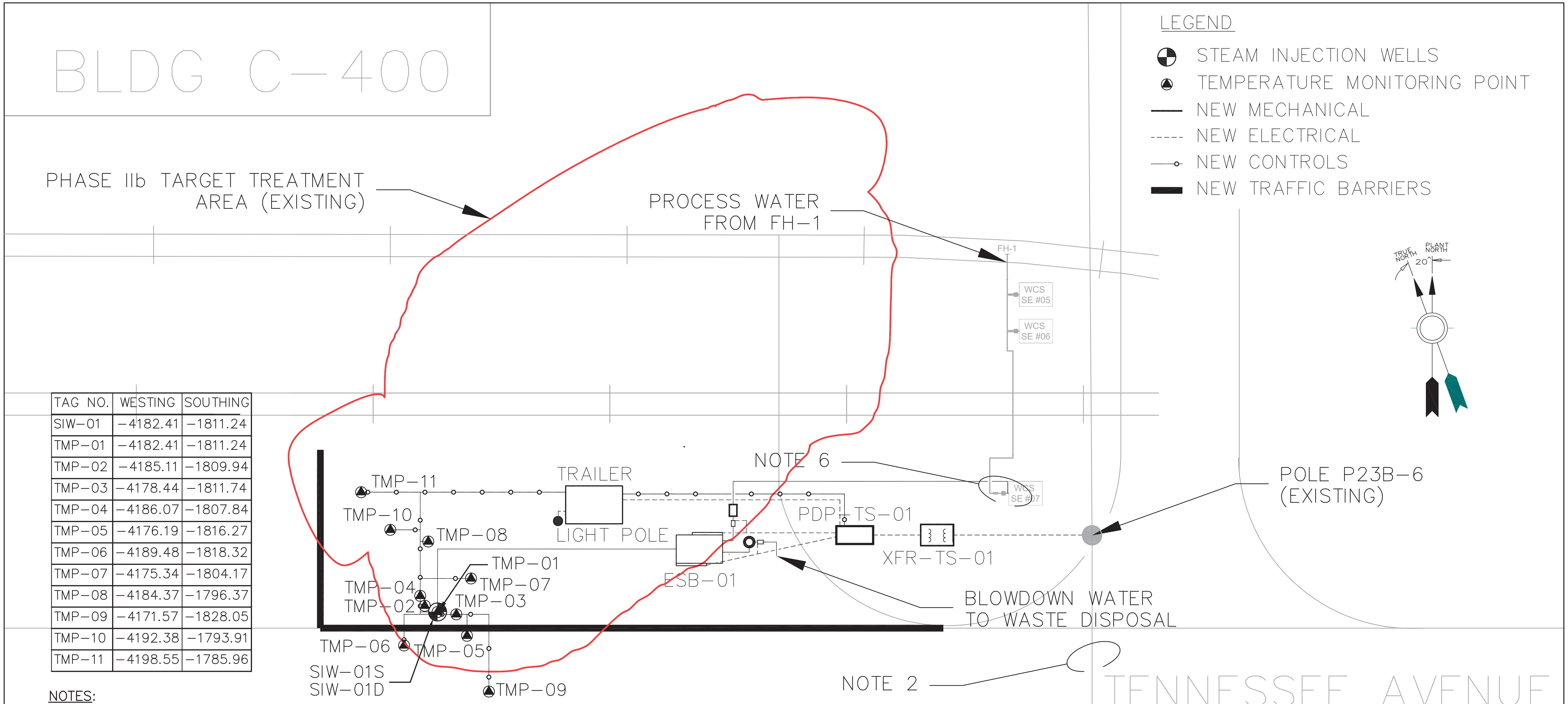
DOE CONTRACT NO. DE-AC30-10CC40020

PROJECT NAME: C-400 STEAM INJECTION TREATABILITY STUDY

TITLE: TREATABILITY STUDY COVER SHEET

CAD FILE NAME	BUILDING	PLANT	CLASS
A001_COVER SHEET.DWG	C-400	PGDP	U

SCALE:	DRAWING NUMBER	REV
AS SHOWN	G7DC40000A001	A



TAG NO.	WESTING	SOUTHING
SIW-01	-4182.41	-1811.24
TMP-01	-4182.41	-1811.24
TMP-02	-4185.11	-1809.94
TMP-03	-4178.44	-1811.74
TMP-04	-4186.07	-1807.84
TMP-05	-4176.19	-1816.27
TMP-06	-4189.48	-1818.32
TMP-07	-4175.34	-1804.17
TMP-08	-4184.37	-1796.37
TMP-09	-4171.57	-1828.05
TMP-10	-4192.38	-1793.91
TMP-11	-4198.55	-1785.96

TO POLE P23B-7

NOTES:

1. REFER TO DRAWING P7DC40000A058 FOR SYMBOLS, ABBREVIATIONS, GENERAL NOTES, AND OTHER REQUIREMENTS.
2. EXISTING OVERHEAD 14.4KV POWER LINES.
3. CONTRACTOR TO FIELD VERIFY SURVEY LOCATIONS PRIOR TO DRILLING AND PROVIDE SURVEY FINAL LOCATIONS AND ELEVATIONS UPON COMPLETION.
4. REFER TO DRAWING C7DC40000A028 FOR WELL AND TMP DETAILS.
5. CONNECT XFR-TS-01 TO EXISTING 14.4KV POWER LINE AT POLE P23B-6.
6. CONNECT ESB-01 FEEDWATER TO EXISTING PROCESS WATER LINE SUPPLIED FROM FIRE HYDRANT FH-1.
7. ROUTINGS AND LOCATIONS ARE DIAGRAMMATIC. INSTALL AS NEEDED TO MAXIMIZE EFFICIENCY.
8. INSTALL ALL PIPING AND CONDUITS NORTH OF JERSEY BARRIERS ABOVEGROUND. PIPING SHALL BE INSTALLED ON PIPE SUPPORTS. CONDUITS CAN LAY DIRECTLY ON GROUND.
9. ROUTE WIRING FROM TMP-05, TMP-06, AND TMP-09 UNDERGROUND TO NORTH OF NEW JERSEY BARRIERS.
10. INSTALL JERSEY TYPE CONCRETE BARRIERS (MINIMUM 40" HEIGHT) ALONG AND NORTH OF TENNESSEE AVENUE AS SHOWN TO PREVENT VEHICULAR ACCESS INTO EQUIPMENT AREA.

0 10 20 30 40 50
FEET

U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

LATA Environmental Services of Kentucky, LLC
managed for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC30-10CC40020 Paducah, Kentucky

Environmental Resources Management
1218 3rd AVENUE, SEATTLE WASHINGTON
(425) 462-8591
ERM

DOE CONTRACT NO. DE-AC30-10CC40020

PROJECT NAME:
C-400 STEAM INJECTION TREATABILITY STUDY

TITLE:
TREATABILITY STUDY SITE PLAN

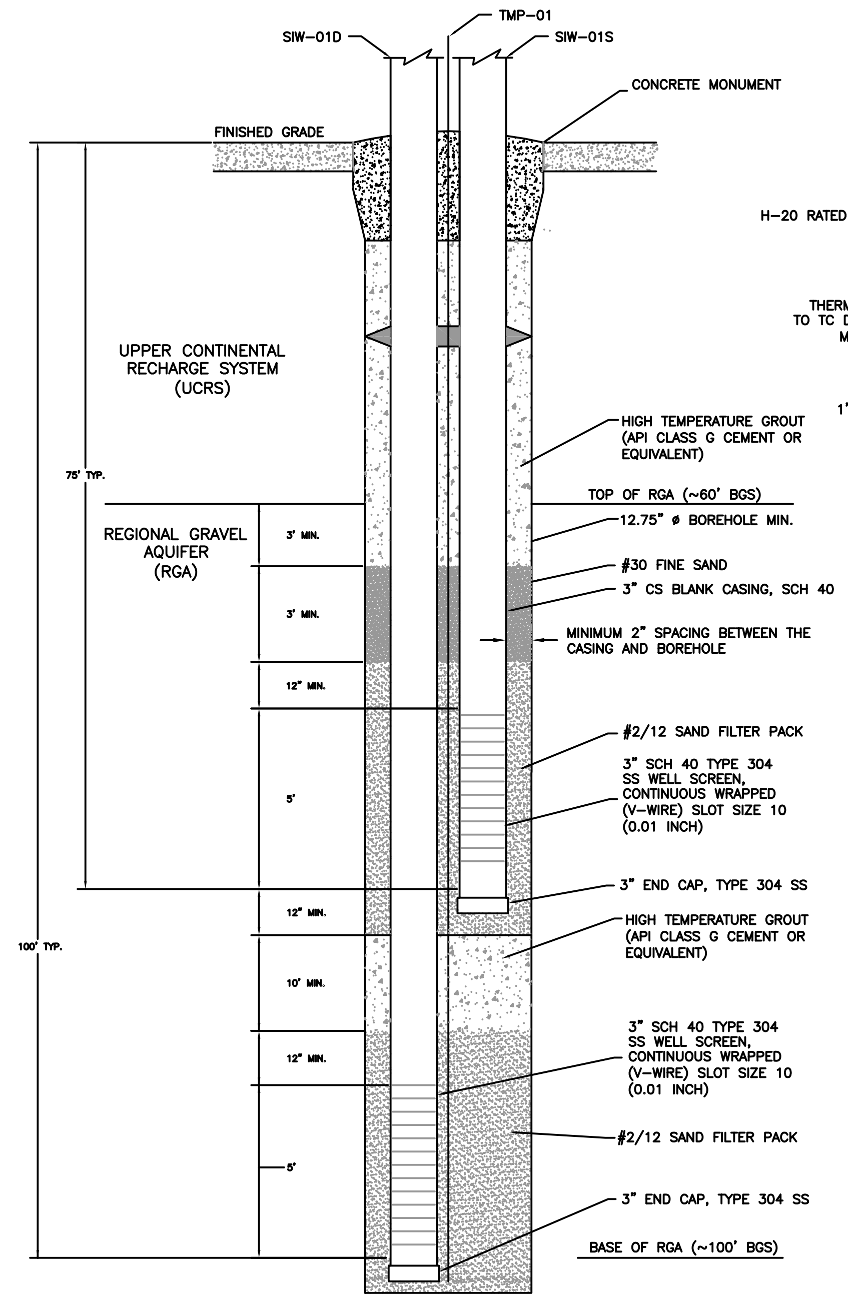
REV.	DATE	DESCRIPTION	DRAWN BY	DRAFT CHK	PROJ ENGR	LEAD ENGR	CONF CTRL/ NUCL SFTY	FAC MGR	E&TS MGR
A	12/9/13	ISSUED FOR REVIEW	JE	JE	CRE	CRE			

DRAWING REVISIONS

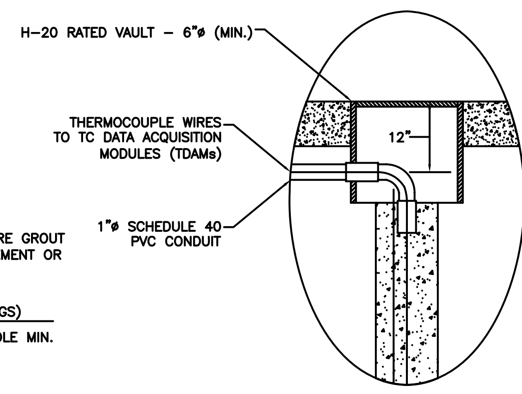
LPE
DATE
PROFESSIONAL SEAL

CAD FILE NAME	BUILDING	PLANT	CLASS
A027_SITE PLAN.DWG	C-400	PGDP	U

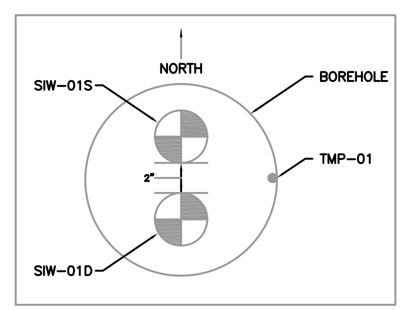
SCALE:	DRAWING NUMBER	REV
AS SHOWN	C7DC40000A027	A



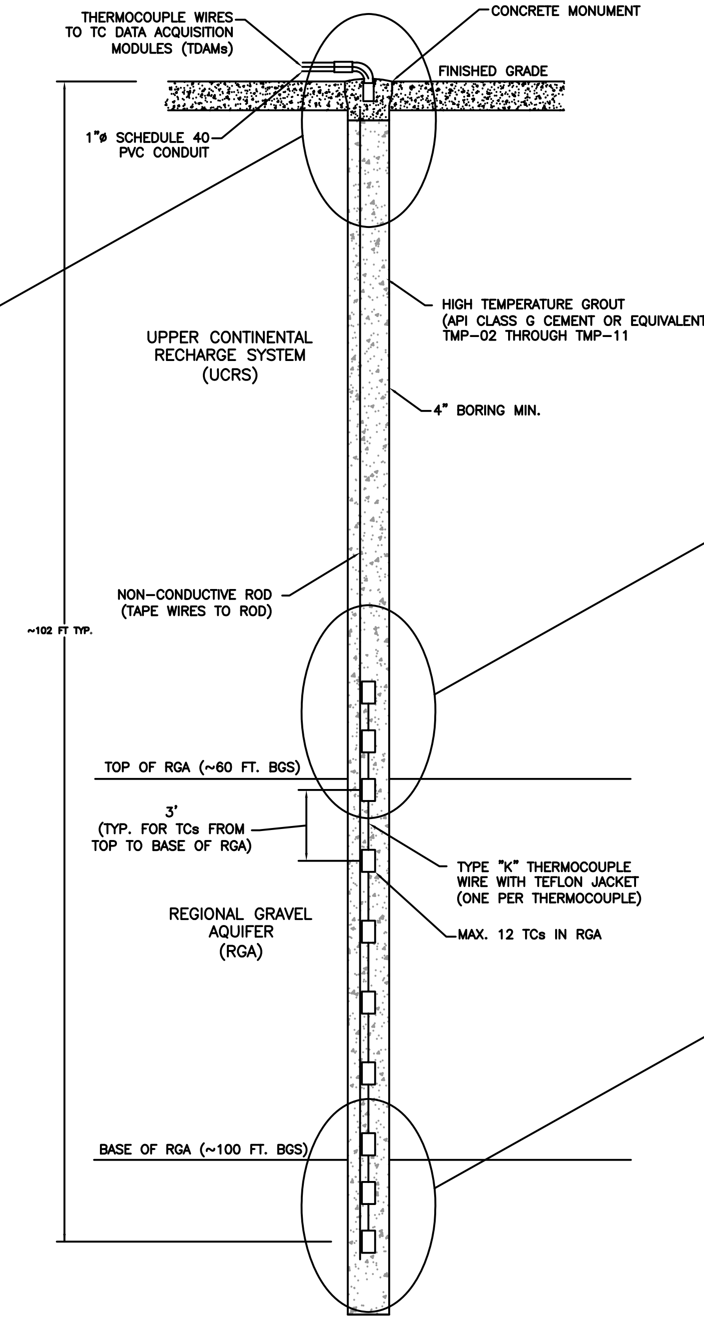
NESTED STEAM INJECTION WELL (TYP.)
(SIW-01S, SIW-01D)
NOT TO SCALE

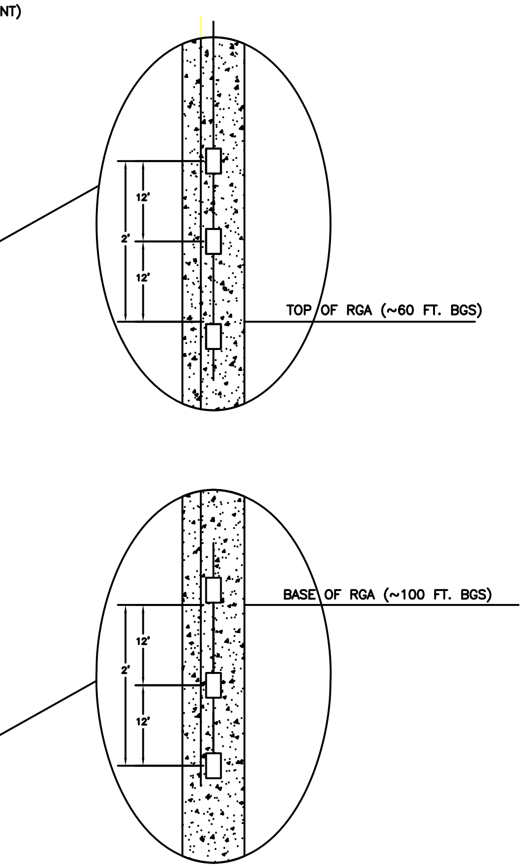


TMP-05
TMP-06
TMP-09



PLAN VIEW
SIW-01S, SIW-01D
NOT TO SCALE





TEMPERATURE MONITORING POINT (TYP.)
(TMP-01 THROUGH TMP-11)
NOT TO SCALE

NOTES:
1. TOP AND BASE OF RGA WILL BE DETERMINED IN FIELD DURING DRILLING.
2. FINAL DEPTH OF THERMOCOUPLES AMD STEAM INJECTION WELLS WILL BE BASED ON FIELD CONDITIONS.
3. MAXIMUM 16 THERMOCOUPLES FOR EACH TMP.
4. ROUTE THERMOCOUPLE CONDUITS ABOVEGROUND ON ORTH SIDE OF JERSEY BARRIERS..
5. FOR TMP-05, TMP-06, AND TMP-09, ROUTE THERMOCOUPLE WIRES UNDERGROUND ON SOUTH SIDE AND ABOVEGROUND ON NORTH SIDE OF JERSEY BARRIERS.
6. FOR EFFICIENCY, THERMOCOUPLE WIRES CAN BE COMBINED INTO LARGER DIAMETER CONDUITS PRIOR TO TDAMs.

REV.	DATE	DESCRIPTION	DRAWN BY	DRAFT CHK	PROJ ENGR	LEAD ENGR	CONF CTRL/ NUCL SFTY	FAC MGR	E&TS MGR
B	2/3/14	ISSUED FOR REVIEW	JE	JE	CRE	CRE			
A	12/9/13	ISSUED FOR REVIEW	JE	JE	CRE	CRE			

DRAWING REVISIONS

LPE

DATE

PROFESSIONAL SEAL

U.S. DEPARTMENT OF ENERGY
PADUCAH, PORTSMOUTH PROJECT OPERATIONS,
PADUCAH GASEOUS DIFFUSION PLANT

LATA Environmental Services of Kentucky, LLC — managed for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC30-10CC40020
Paducah, Kentucky

Environmental Resources Management
1218 3rd AVENUE, SEATTLE WASHINGTON
(425) 462-8591

DOE CONTRACT NO. DE-AC30-10CC40020

PROJECT NAME:
C-400 STEAM INJECTION TREATABILITY STUDY

TITLE:
TREATABILITY STUDY STEAM INJECTION WELLS AND TEMPERATURE MONITORING POINTS

CAD FILENAME	BUILDING	PLANT	CLASS
A028_SIW & TMP DETAILS.DWG	C-400	PGDP	U

SCALE:	DRAWING NUMBER	REV
N.T.S.	C7DC40000A028	B

GENERAL EQUIPMENT

- COOLING TOWER
- PRESSURE VESSEL
- FLAT BOTTOM TANK w/CLOSED TOP
- CONE BOTTOM TANK
- SLANT PLATE CLARIFIER OR SEPARATOR
- AIR COMPRESSOR
- HEAT EXCHANGER FOR VAPOR SERVICE (FIN TUBE)
- ELECTRIC HEAT EXCHANGER
- HEAT EXCHANGER FOR LIQUID SERVICE (PLATE OR SHELL & TUBE)
- CENTRIFUGAL FAN
- CENTRIFUGAL PUMP
- ROTARY PUMP
- DIAPHRAGM PUMP
- VACUUM BLOWER
- FAN (FAN)
- CENTRIFUGAL PUMP (IN TANK) (M)
- ELECTRICAL COIL HEATER (STEAM)

GENERAL EQUIPMENT (cont'd)

- ROTARY, CENTRIFUGAL & WATER SEALED COMPRESSORS & VACUUM PUMPS
- SUMP PUMP (M)
- BLOWER SILENCER

GENERAL PIPING

- PRIMARY PROCESS FLOW
- SECONDARY PROCESS OR UTILITY FLOW
- CAM LOCK CONNECTION
- SOLIDS FLOW OR INTERMITTENT FLOW
- CONCENTRIC REDUCER OR INCREASER
- ECCENTRIC REDUCER OR INCREASER
- FLEXIBLE CONNECTION WITH QUICK CONNECTS
- FLEXIBLE HOSE WITH FLANGED ENDS
- FLANGED JOINT
- BLANK FLANGED
- DRAIN
- STEAM TRAP WITH INTEGRAL STRAINER
- ATMOSPHERIC VENT
- PIPE SLOPE
- BASKET STRAINER, BAG FILTER, OR MOISTURE SEPARATOR
- INSULATION
- INSULATION & HEAT TRACE
- ENERGY METER
- STRAINER
- STEAM BOILER

MISCELLANEOUS

DWG.# — LINE BREAK OR RESUMPTION POINT

VALVE NOTATION

CONTROL VALVE BODIES

OPEN / CLOSED

- GATE (GA)
- BALL (BA)
- BUTTERFLY (BF)
- NEEDLE (NE)
- CHECK (CK)
- GLOBE (GL)
- STOP CHECK (SC)

DIAPHRAGM ACTUATED VALVES (TYPICAL)

HV

NO — NORMAL MODE (*SEE NOTE BELOW*)

FC — FAILURE MODE – FO,FC,FL,FI

NOTE:
FAIL POSITIONS ALL BODY STYLES
FO – FAIL OPEN
FC – FAIL CLOSED
FL – FAIL LOCKED/LAST POSITION
FI – FAIL INDETERMINATE
CSO – CAR SEAL/LOCK OPEN
CSC – CAR SEAL/LOCK CLOSED

NORMAL MODE IDENTIFICATION (I.E. NO. NC.) SHOULD ONLY BE USED FOR ON-OFF TYPE VALVES WHOSE POSITION CANNOT BE SHOWN BY SHADING THE VALVE BODY.

VALVE ACTUATORS

- HAND OR HAND WHEEL
- PNEUMATIC DIAPHRAGM
- SOLENOID (S)
- FLOAT

INSTRUMENT IDENTIFICATION

CT	CURRENT TRANSFORMER
EI	ENERGY INDICATION
ET	ENERGY TRANSMITTER
PG	PRESSURE GAUGE
PH	PHASE
KV	KILO VOLTAGE
VAC	VOLTS ALTERNATING CURRENT
VDC	VOLTS DIRECT CURRENT

GENERAL INSTRUMENTS

- INSTRUMENT FOR SINGLE MEASURED VARIABLE AND ANY NUMBER OF FUNCTIONS. INSTRUMENT IS FIELD MOUNTED
- INSTRUMENT IS MOUNTED IN FRONT OF LOCAL PANEL.
- CENTRAL PLC OR COMPUTER

GENERAL INSTRUMENTS (cont'd)

ALARM & CONTROL DESIGNATIONS

S/S, HH, H, L, LL — 0-100%

HH – HI-HI ALARM (CONTROL ROOM)
H – HI ALARM (CONTROL ROOM)
L – LO ALARM (CONTROL ROOM)
LL – LO-LO ALARM (CONTROL ROOM)
S/S – START/STOP FROM CONTROL ROOM
0-100% – ADJUSTABLE RANGE OF OUTPUT
HOA – HAND/OFF/AUTO
OCA – OPEN/CLOSED/AUTO

- CONNECTION TO PROCESS OR INSTRUMENT INPUT
- ELECTRICAL SIGNAL OR INTERNAL SYSTEM LINK

TYPICAL CONNECTION ANY VARIABLE

- DIRECT CONNECTION PROCESS WITH ISOLATION VALVE

PRESSURE SENSOR CONNECTIONS

- DIRECT CONNECTED
- SIPHON TUBE

LINE NUMBER IDENTIFICATION

STM-100-4"-A

- MATERIAL SPECIFICATION
  - A – SCHEDULE 40 CARBON STEEL
  - B – SCHEDULE 40 PVC
  - C – SCHEDULE 40 GALVANIZED STEEL
  - T – STAINLESS STEEL TUBING
  - H – STAINLESS STEEL HOSE
- LINE SIZE
- SEQUENTIAL NUMBER
- FLOW TYPE
  - BDW – BLOWDOWN WATER
  - FWS – FEEDWATER
  - STM – STEAM

SELF-ACTIVATED PRESSURE DEVICES

- PRV — PRESSURE REDUCING REGULATOR WITH SENSOR TUBING ON DOWNSTREAM SIDE
- PSE — RUPTURE DISK OR SAFETY HEAD FOR PRESSURE RELIEF
- PRV — PRESSURE RELIEF VALVE

EQUIPMENT NUMBER IDENTIFICATION

ESB-100

- SEQUENCE NUMBER
- EQUIPMENT LETTER (SEE BELOW)

CV	CONTROL VALVE
ESB	ELECTRIC STEAM BOILER
FH	FIRE HYDRANT
HV	HAND VALVE
LC	LOAD CENTER
MMI	MAN-MACHINE INTERFACE
MS	MOISTURE SEPARATOR
P	POLE
PDP	POWER DISTRIBUTION PANEL
PRV	PRESSURE REGULATING VALVE
RGSC	RIGID GALVANIZED STEEL CONDUIT
SIW	STEAM INJECTION WELL
TC	THERMOCOUPLE
TS	TREATABILITY STUDY
TMP	TEMPERATURE MONITORING POINT
XFR	TRANSFORMER

SECTION AND DETAIL KEY

- SECTION NUMBER OR DETAIL LETTER
- DRAWING ON WHICH SECTION OR DETAIL IS TAKEN
- DRAWING ON WHICH SECTION OR DETAIL IS SHOWN

PIPE INSPECTION AND TEST REQUIREMENTS

FLUID SERVICE	NON-CODE < 15 PSIG (FROM -20 TO 366°F)	ASME B31.3, CATEGORY D ≤ 150 PSIG (FROM -20 TO 366°F)	ASME B31.3, NORMAL > 15 PSIG AND NOT SPECIFIED CATEGORY D
CODE OF RECORD	NON-CODE	ASME B31.3 – 2012	ASME B31.3 – 2012
VISUAL INSPECTION REQUIRED	NONE	TO SATISFACTION OF CODE QUALIFIED EXAMINER	5% FABRICATION 100% LONGITUDINAL WELDS
RADIOGRAPHY REQUIRED	NONE	NONE	5% CIRCUMFERENTIAL AND MITER GROOVE WELDS OF EACH WELDER
TYPE OF LEAK TEST	NONE	PNEUMATIC/HYDROSTATIC	HYDROSTATIC
TEST PRESSURE	N/A	1.1/1.5 TIMES DESIGN PRESSURE	1.5 TIMES DESIGN PRESSURE
TEST DURATION	N/A	10 MIN. AT FULL TEST PRESSURE	10 MIN. AT FULL TEST PRESSURE
TEST PRESSURE TOLERANCE	N/A	+10%, -0%	+10%, -0%

GENERAL NOTES

1. DRAWINGS ARE DIAGRAMMATIC AND CANNOT SHOW ALL DETAILS. PROVIDE ALL FITTINGS AND COMPONENTS FOR COMPLETE SYSTEM.
2. COMPONENTS SHALL BE INSTALLED PER MANUFACTURER REQUIREMENTS.
3. COMPONENTS SHALL BE INSTALLED WITH SUFFICIENT CLEARANCE FOR OPERATION AND MAINTENANCE.
4. FLOW METERS, GAUGES, AND INSTRUMENTATION SHALL NOT BE SUBJECT TO PRESSURE TESTING UNLESS ALLOWED BY MANUFACTURER.
5. ALL CODED PIPING AND COMPONENTS SHALL BE QUALIFIED TO ASME B31.3 UNLESS OTHERWISE EXCLUDED.
6. STEAM HOSES SHALL HAVE DOUBLE-BRAIDED STAINLESS STEEL JACKET AND CLASS 150 L/J FLANGES.
7. WELL CASING AND SUBSURFACE COMPONENTS ARE NON-CODE.

U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

LATA Environmental Services of Kentucky, LLC — managed for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC30-10CC40020 Paducah, Kentucky

ERM — Environmental Resources Management
1218 3rd AVENUE, SEATTLE WASHINGTON
(425) 462-8591

DOE CONTRACT NO. DE-AC30-10CC40020

PROJECT NAME: C-400 STEAM INJECTION TREATABILITY STUDY

TITLE: TREATABILITY STUDY SYMBOLS, IDENTIFICATION, ABBREVIATIONS, NOTES, AND REQUIREMENTS

CAD FILE NAME	BUILDING	PLANT	CLASS
A058_MECHANCAL LEGEND.DWG	C-400	PGDP	U

SCALE:	DRAWING NUMBER	REV
AS SHOWN	P7DC40000A058	A

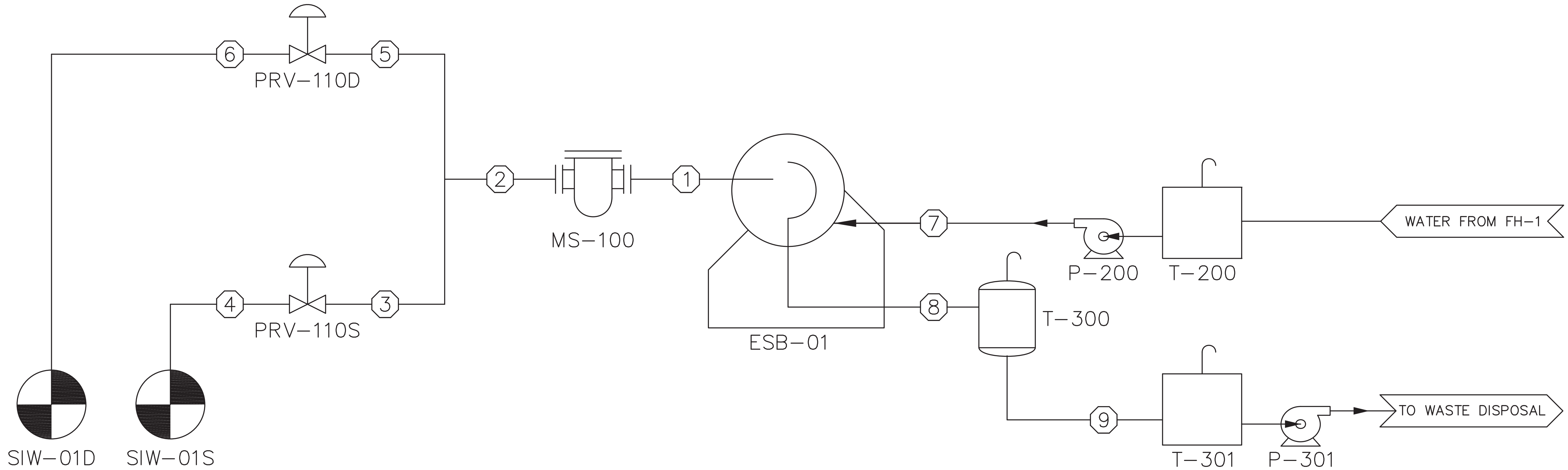
LPE

DATE

PROFESSIONAL SEAL

REV.	DATE	DESCRIPTION	DRAWN BY	DRAFT CHK	PROJ ENGR	LEAD ENGR	CONF CTRL/ NUCL SFTY	FAC MGR	ENTS MGR
A	12/9/13	ISSUED FOR REVIEW	JE	JE	CRE	CRE			

DRAWING REVISIONS



NO.	DESCRIPTION	FLOWRATE	PRESSURE	TEMPERATURE	QUALITY	ENTHALPY
1	STEAM	6,000 LB/HR	110 PSIG	344.22°F	98 %	1,174.16 BTU/LB
2	STEAM	6,000 LB/HR	110 PSIG	344.22°F	100 %	1,191.68 BTU/LB
3	STEAM	3,000 LB/HR	110 PSIG	344.22°F	100 %	1,191.68 BTU/LB
4	STEAM	3,000 LB/HR	35 PSIG	280.66°F	100 %	1,174.31 BTU/LB
5	STEAM	3,000 LB/HR	110 PSIG	344.22°F	100 %	1,191.68 BTU/LB
6	STEAM	3,000 LB/HR	45 PSIG	292.42°F	100 %	1,177.92 BTU/LB
7	FEEDWATER	12.8 GPM	125 PSIG	60°F	0 %	28.46 BTU/LB
8	BLOWDOWN	5 GPM	110 PSIG	344.22°F	0 %	315.76 BTU/LB
9	BLOWDOWN	5 GPM	5 PSIG	227.15°F	0 %	195.48 BTU/LB

NOTES:

1. SPECIFIED VALUES ARE MAXIMUMS.
2. BLOWDOWN IS INTERMITTENT (APPROXIMATELY 30 GALLONS FOR 10 SECONDS EVERY 12 TO 24 HOURS).

LPE	REV.	DATE	DESCRIPTION	DRAWN BY	DRAFT CHK	PROJ ENGR	LEAD ENGR	CONF CTRL/ NUCL SFTY	FAC MGR	E&TS MGR
	B	2/3/14	ISSUED FOR REVIEW	JE	JE	CRE	CRE			
	A	12/9/13	ISSUED FOR REVIEW	JE	JE	CRE	CRE			
DATE										
PROFESSIONAL SEAL			DRAWING REVISIONS							

U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

LATA Environmental Services of Kentucky, LLC
managed for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC30-10CC40020 Paducah, Kentucky

ERM
Environmental Resources Management
1218 3rd AVENUE, SEATTLE WASHINGTON
(425) 462-8591

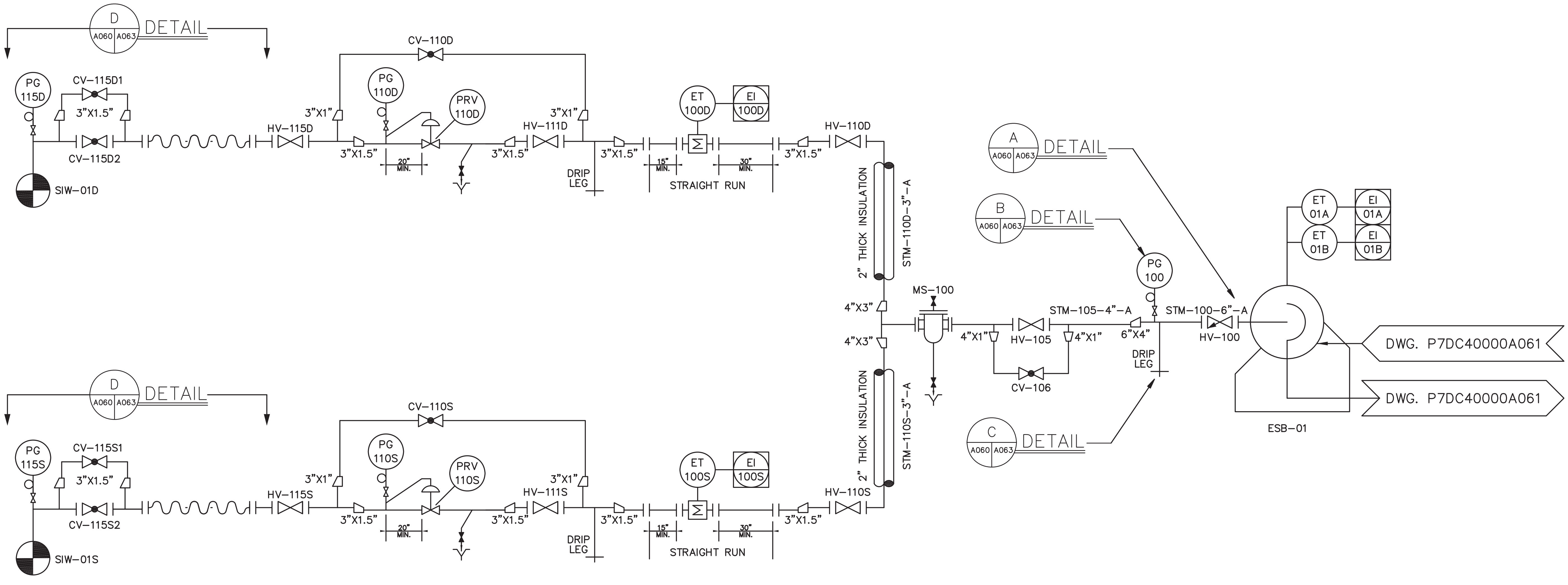
DOE CONTRACT NO. DE-AC30-10CC40020

PROJECT NAME: C-400 STEAM INJECTION TREATABILITY STUDY

TITLE: TREATABILITY STUDY PROCESS FLOW DIAGRAM

CAD FILE NAME	BUILDING	PLANT	CLASS
A059_PFD.DWG	C-400	PGDP	U

SCALE:	DRAWING NUMBER	REV
NOT TO SCALE	P7DC40000A059	B



NOTES:

1. REFER TO DRAWING P7DC40000A058 FOR SYMBOLS, ABBREVIATIONS, GENERAL NOTES, AND OTHER REQUIREMENTS.
2. SLOPE STEAM PIPING AND HOSES $\frac{1}{8}$ INCH PER FOOT (MINIMUM) IN DIRECTION OF FLOW.
3. INSULATE STEAM PIPE, VALVES, AND FITTINGS AS PER SPECIFICATIONS.
4. REFER TO DRAWING P7DC40000A063 FOR PIPE SUPPORT, DRAIN, AND STEAM TRAP REQUIREMENTS AND DETAILS.
5. ALL TUBING SHALL BE 316 STAINLESS STEEL WITH APPROPRIATE STEAM RATED FITTINGS.
6. STEAM HOSES SHALL HAVE DOUBLE-BRAIDED STAINLESS STEEL JACKET AND CLASS 150 FLANGES. AT LEAST ONE FLANGE SHALL BE LAP JOINT TYPE.
7. VALVES SHALL BE ORIENTED FOR OPTIMUM ACCESSIBILITY WITHOUT NEED FOR LADDER.
8. INSTALL STEAM BOILER AND 24VDC INSTRUMENTS IN WEATHER PROOF ENCLOSURES.
9. INSTALL STRAINERS WITH BASKET IN HORIZONTAL PLANE.
10. INSTALL PIPE SUPPORTS EACH SIDE OF HOSES, REGULATORS, AND AT LEAST EVERY 10 FEET FROM STEAM BOILER.
11. INSTALL APPROPRIATELY SIZED REDUCERS BASED ON SELECTED METER, PRESSURE REGULATOR, AND VALVE FLOW COEFFICIENTS.

LPE

DATE

PROFESSIONAL SEAL

REV.	DATE	DESCRIPTION	DRAWN BY	DRAFT CHK	PROJ ENGR	LEAD ENGR	CONF CTRL/ NUCL SFTY	FAC MGR	ENTS MGR
B	2/3/14	ISSUED FOR REVIEW	JE	JE	CRE	CRE			
A	12/9/13	ISSUED FOR REVIEW	JE	JE	CRE	CRE			

DRAWING REVISIONS

U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

LATA Environmental Services of Kentucky, LLC
managed for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC30-10CC40020 Paducah, Kentucky

ERM
Environmental Resources Management
1218 3rd AVENUE, SEATTLE WASHINGTON
(425) 462-8591

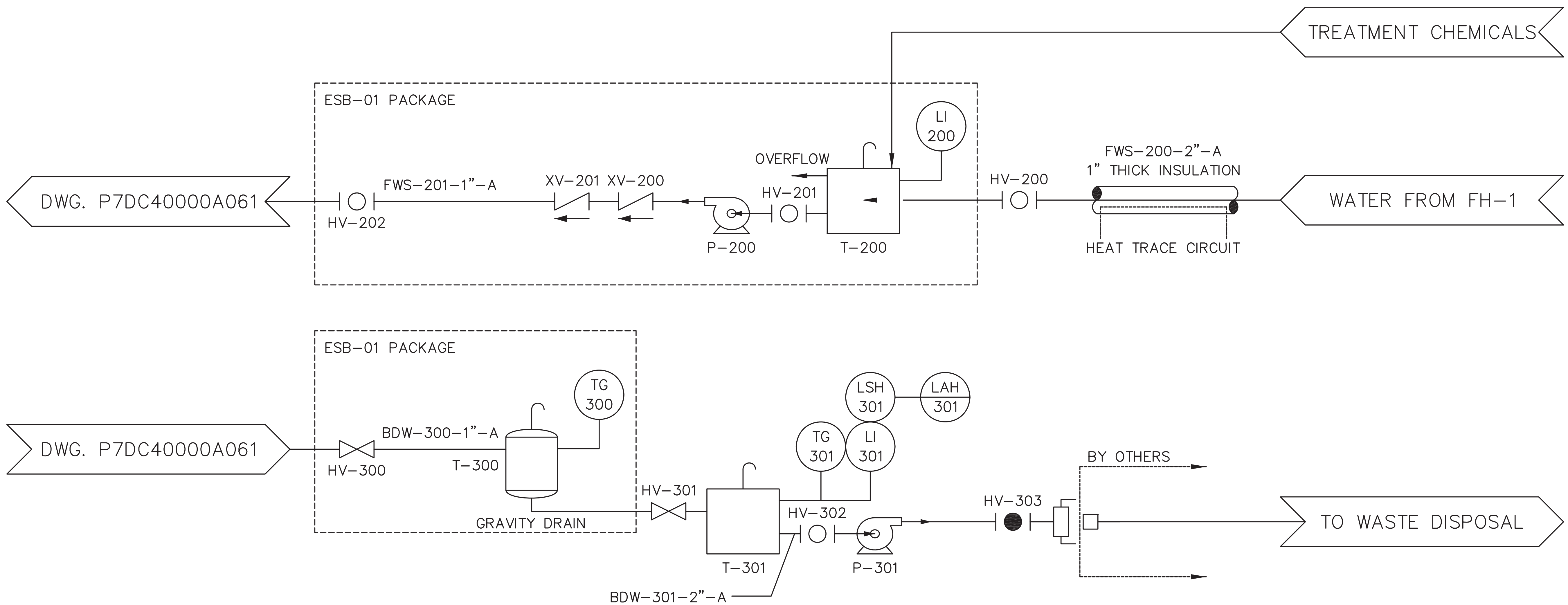
DOE CONTRACT NO. DE-AC30-10CC40020

PROJECT NAME:
C-400 STEAM INJECTION TREATABILITY STUDY

TITLE:
TREATABILITY STUDY
PIPING & INSTRUMENTATION DIAGRAM
SHEET 1

CAD FILE NAME	BUILDING	PLANT	CLASS
A060_P&ID SH1.DWG	C-400	PGDP	U

SCALE:	DRAWING NUMBER	REV
NOT TO SCALE	P7DC40000A060	B



NOTES:

1. REFER TO DRAWING P7DC40000A058 FOR SYMBOLS, ABBREVIATIONS, GENERAL NOTES, AND OTHER REQUIREMENTS.
2. INSULATE PIPING, VALVES, AND TANKS AS PER SPECIFICATIONS.
3. INSTALL INSULATION AND HEAT TRACE CABLES ON PIPING AND VALVE BETWEEN T-301 AND P-301. POWER HEAT TRACE CABLES FROM LC1.
4. INSTALL PIPE SUPPORTS AT LEAST EVERY 5 FEET FROM STEAM BOILER. REFER TO DRAWING P7DC40000A063 FOR DETAILS.
5. VALVES SHALL BE ORIENTED FOR OPTIMUM ACCESSIBILITY WITHOUT NEED FOR LADDER.
6. CONNECT FEEDWATER INTO EXISTING WATER LINE FROM FIRE HYDRANT NO. 1. REFER TO DRAWING P7DC40000A063 FOR DETAILS.
7. STORE BLOWDOWN IN TANK T-301 FOR FUTURE DISPOSAL (BY OTHERS).
8. FOR TANK T-301, PROVIDE HIGH LEVEL FLOAT WITH LOCAL ALARM (LSH-301/LAH-301) BY HYDROMATIC MODEL Q-ALERT XT, OR EQUAL.

REV.	DATE	DESCRIPTION	DRAWN BY	DRAFT CHK	PROJ ENGR	LEAD ENGR	CONF CTRL/ NUCL SFTY	FAC MGR	E&TS MGR
A	12/9/13	ISSUED FOR REVIEW	JE	JE	CRE	CRE			

DRAWING REVISIONS

LPE

DATE

PROFESSIONAL SEAL

U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

LATA Environmental Services of Kentucky, LLC
managed for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC30-10CC40020 Paducah, Kentucky

Environmental Resources Management
1218 3rd AVENUE, SEATTLE WASHINGTON
(425) 462-8591

DOE CONTRACT NO. DE-AC30-10CC40020

PROJECT NAME: C-400 STEAM INJECTION TREATABILITY STUDY

TITLE: TREATABILITY STUDY PIPING & INSTRUMENTATION DIAGRAM SHEET 2

CAD FILE NAME	BUILDING	PLANT	CLASS
A061_P&ID SH2.DWG	C-400	PGDP	U

SCALE:	DRAWING NUMBER	REV
NOT TO SCALE	P7DC40000A061	A

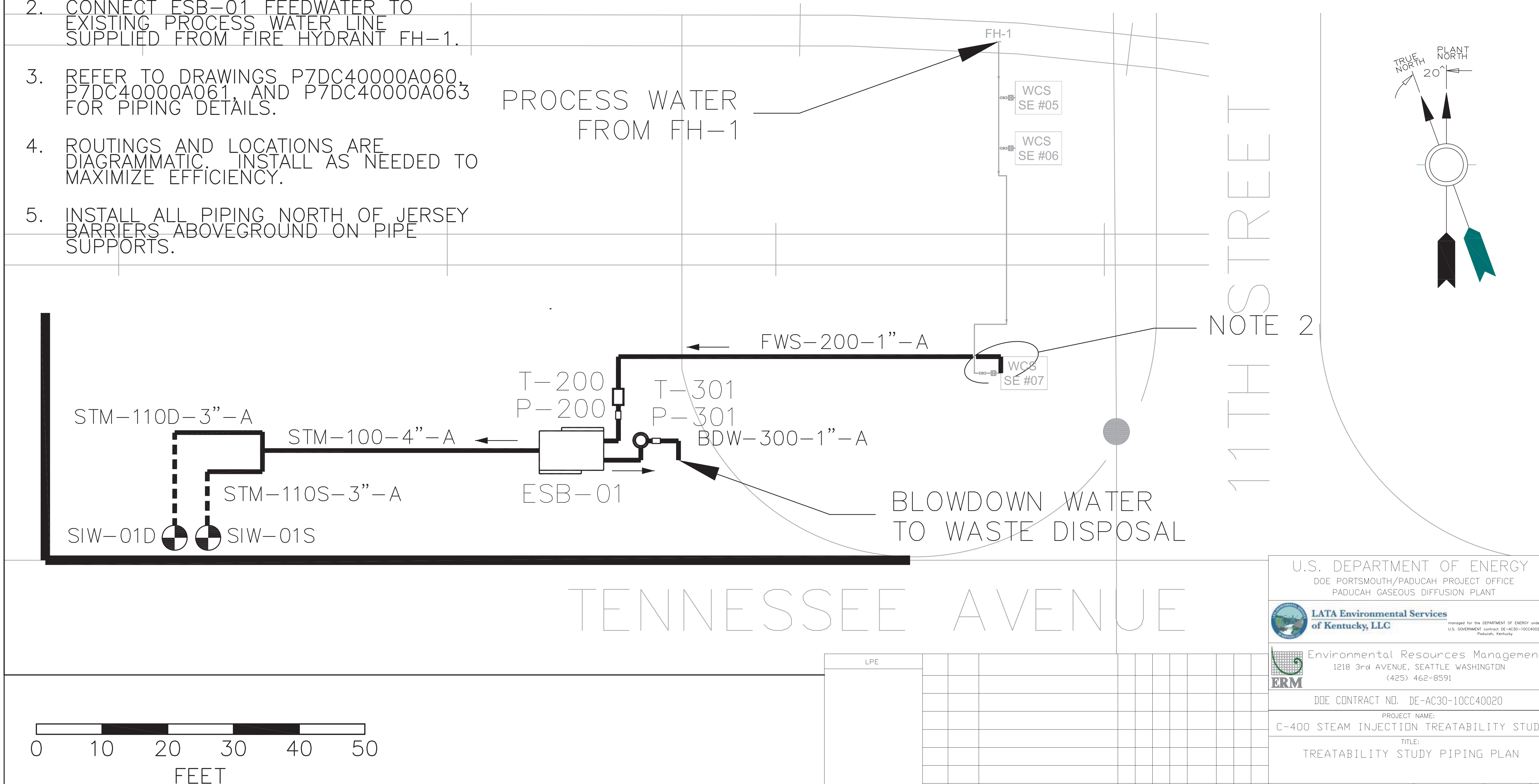
BLDG C-400

NOTES:

1. REFER TO DRAWING P7DC40000A058 FOR SYMBOLS, ABBREVIATIONS, GENERAL NOTES, AND OTHER REQUIREMENTS.
2. CONNECT ESB-01 FEEDWATER TO EXISTING PROCESS WATER LINE SUPPLIED FROM FIRE HYDRANT FH-1.
3. REFER TO DRAWINGS P7DC40000A060, P7DC40000A061, AND P7DC40000A063 FOR PIPING DETAILS.
4. ROUTINGS AND LOCATIONS ARE DIAGRAMMATIC. INSTALL AS NEEDED TO MAXIMIZE EFFICIENCY.
5. INSTALL ALL PIPING NORTH OF JERSEY BARRIERS ABOVEGROUND ON PIPE SUPPORTS.

LEGEND

- STEAM INJECTION WELLS
- NEW PIPING AND EQUIPMENT
- NEW HOSES
- NEW TRAFFIC BARRIERS



U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

LATA Environmental Services of Kentucky, LLC
managed for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC30-10CC40020 Paducah, Kentucky

Environmental Resources Management
1218 3rd AVENUE, SEATTLE WASHINGTON
(425) 462-8591
ERM

DOE CONTRACT NO. DE-AC30-10CC40020

PROJECT NAME: C-400 STEAM INJECTION TREATABILITY STUDY

TITLE: TREATABILITY STUDY PIPING PLAN

CAD FILE NAME	BUILDING	PLANT	CLASS
A062_PIPING PLAN.DWG	C-400	PGDP	U

SCALE:	DRAWING NUMBER	REV
AS SHOWN	P7DC40000A062	A

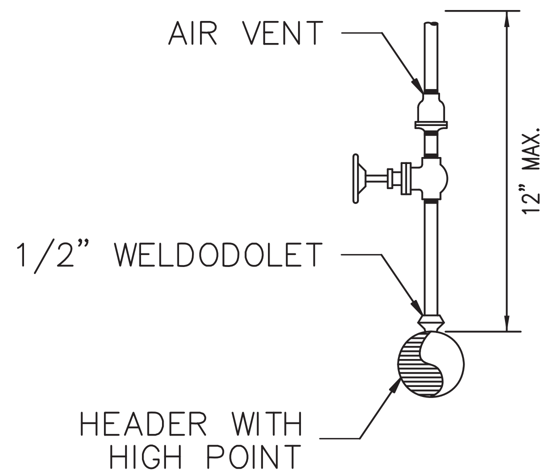
LPE

REV.	DATE	DESCRIPTION	DRAWN BY	DRAFT CHK	PROJ ENGR	LEAD ENGR	CONF CTRL/ NUCL SFTY	FAC MGR	E&TS MGR
A	12/9/13	ISSUED FOR REVIEW	JE	JE	CRE	CRE			

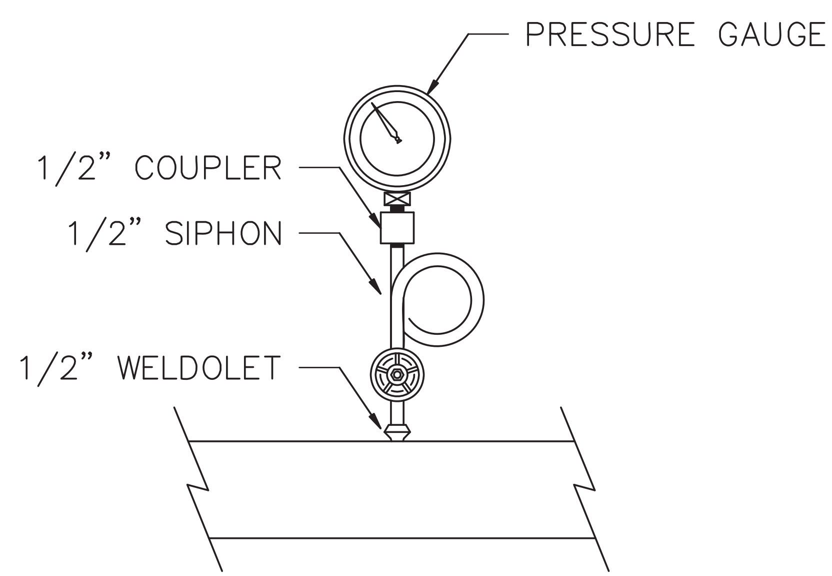
DRAWING REVISIONS

DATE

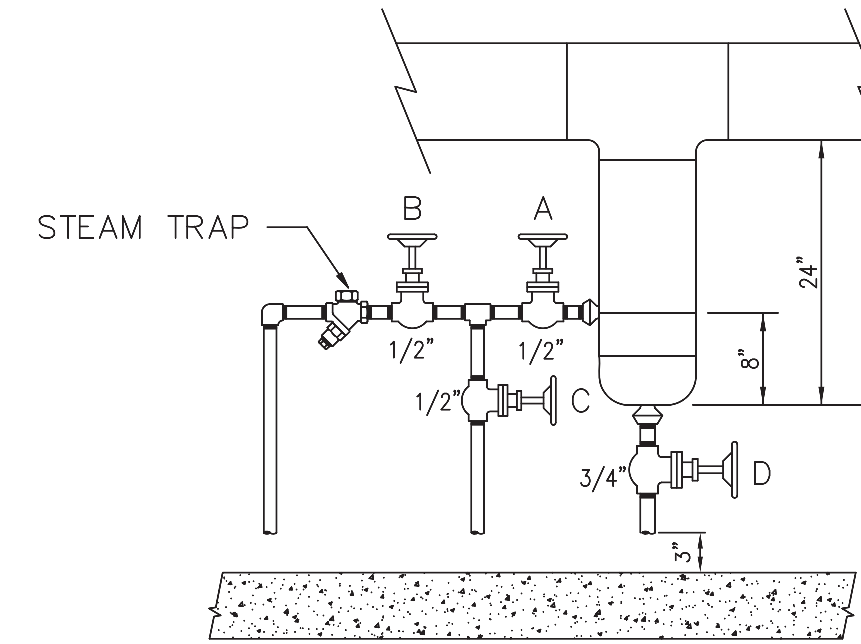
PROFESSIONAL SEAL



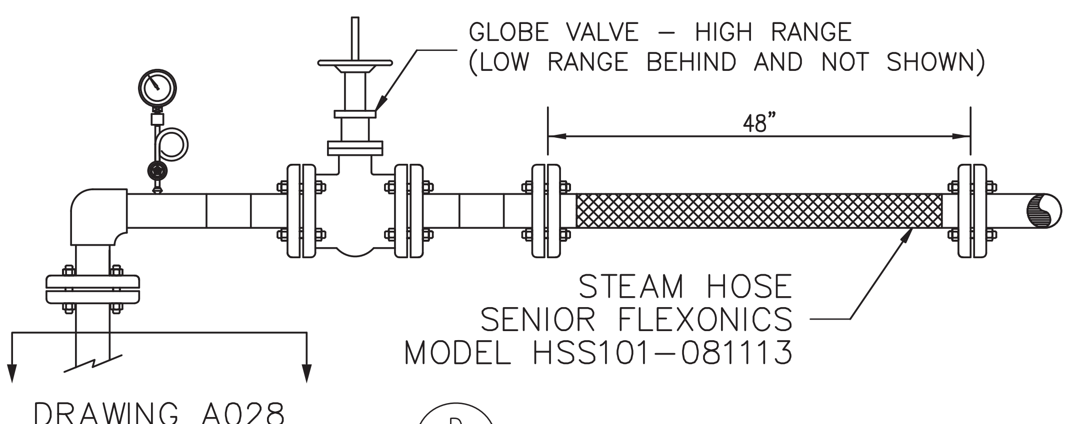
A A060 A063 DETAIL – VENT (TYP.)
NTS



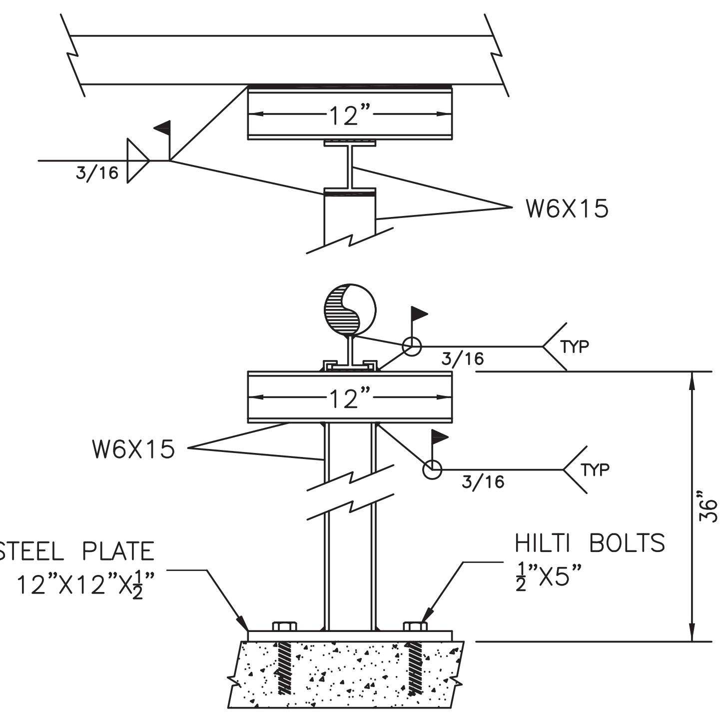
B A060 A063 DETAIL – PRESSURE GAUGE (TYP.)
NTS



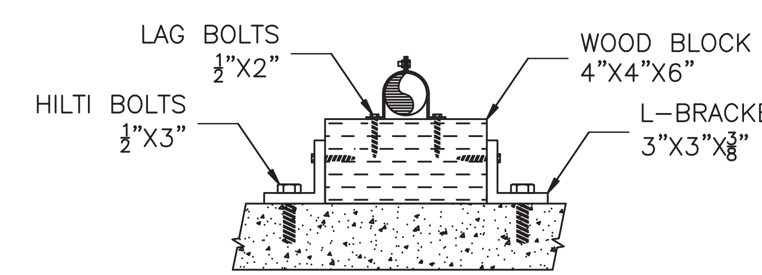
C A060 A063 DETAIL – DRIP LEG (TYP.)
NTS



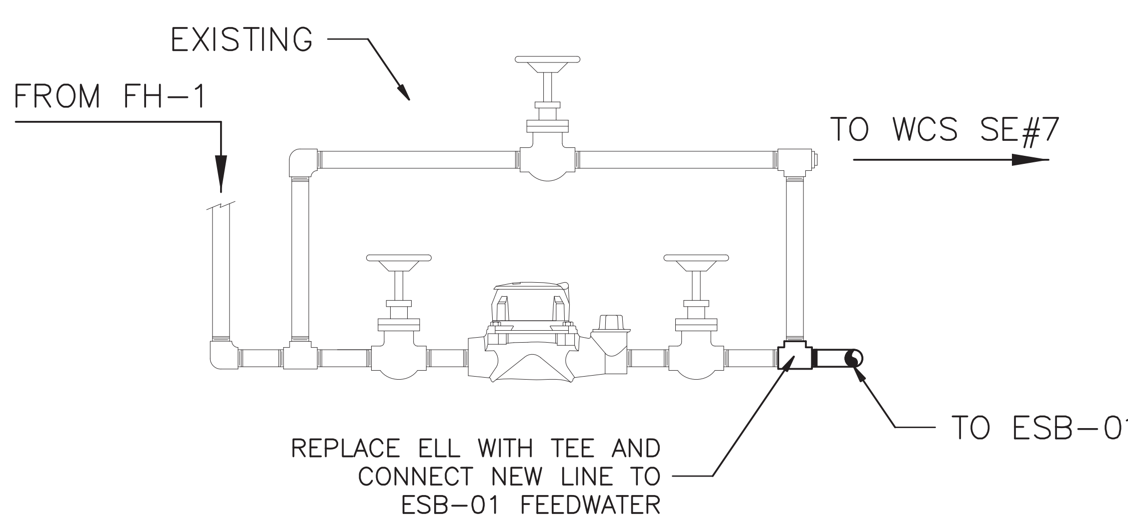
D A060 A063 DETAIL – WELLHEAD (TYP.)
NTS



E A060 A063 DETAIL – STEAM PIPE SUPPORT (TYP.)
NTS



F A061 A063 DETAIL – WATER PIPE SUPPORT (TYP.)
NTS



G A060 A063 DETAIL – FEEDWATER CONNECTION
NTS

REV.	DATE	DESCRIPTION	DRAWN BY	DRAFT CHK	PROJ ENGR	LEAD ENGR	CONF CTRL/ NUCL SFTY	FAC MGR	EATS MGR
B	2/3/14	ISSUED FOR REVIEW	JE	JE	CRE	CRE			
A	12/9/13	ISSUED FOR REVIEW	JE	JE	CRE	CRE			

DRAWING REVISIONS

LPE
DATE
PROFESSIONAL SEAL

U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

LATA Environmental Services of Kentucky, LLC
managed for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC30-10CC40020 Paducah, Kentucky

Environmental Resources Management
1218 3rd AVENUE, SEATTLE WASHINGTON
(425) 462-8591
ERM

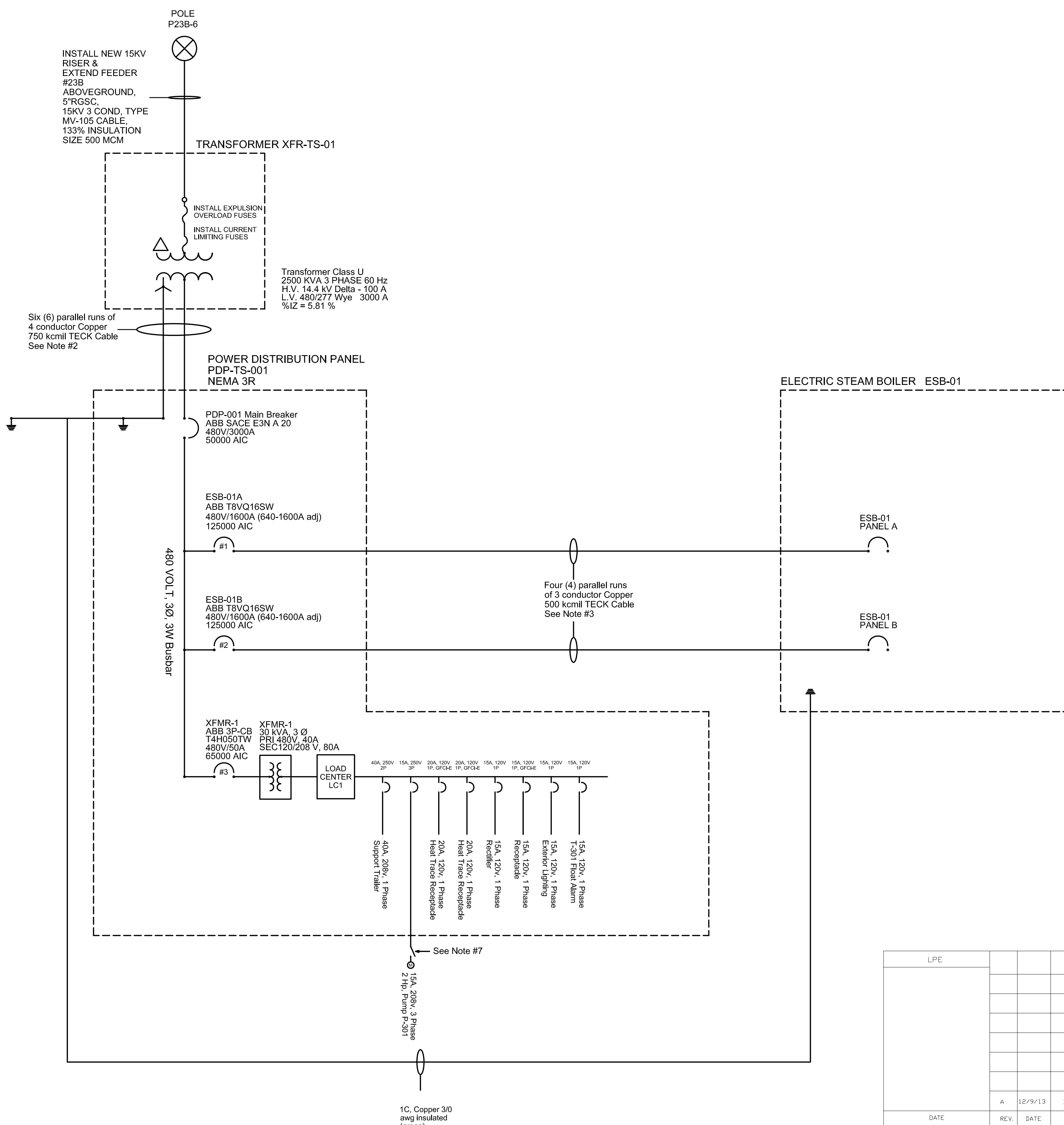
DOE CONTRACT NO. DE-AC30-10CC40020

PROJECT NAME:
C-400 STEAM INJECTION TREATABILITY STUDY

TITLE:
TREATABILITY STUDY
WELLHEAD AND PIPING DETAILS

CAD FILE NAME	BUILDING	PLANT	CLASS
A063_WELLHEAD & PIPING DETAILS.DWG	C-400	PGDP	U

SCALE:	DRAWING NUMBER	REV
NOT TO SCALE	P7DC40000A063	B



General Notes

1. Construction and material shall comply with Kentucky building code, CSA/UL, National Electrical Code and applicable local and state codes.

2. Cable from Transformer XFR-TS-01 to PDP-TS-001: Six (6) parallel 4C-750 kcmil Cu conductor TECK cables. (4C) HL TECK: Four Conductor (COPPER), XLP Insulated, PVC Inner Jacket, Aluminum or Steel Armor, PVC Outer Jacket, Bare Copper Ground Conductor, 600 Volts. USA Wire & Cable Inc. Part# 750-04WGTECK90 or equivalent

3. Cable from PDP-TS-001 Breaker #1 & #2 to Electric Steam Boiler ESB-01 Panel A & B: Four (4) parallel 3C-500 kcmil Copper conductor TECK cables. (3C) HL TECK: Three Conductor (COPPER), XLP Insulated, PVC Inner Jacket, Aluminum or Steel Armor, PVC Outer Jacket, Bare Copper Ground Conductor, 600 Volts. USA Wire & Cable Inc. Part# 500-03WGTECK90 or equivalent.

4. XFMR-1 and Load Center LC1 are internal to PDP-TS-001. Support Trailer, P-301, Heat Trace, Control and Lighting circuits are to be connected to breakers in LC1.

5. All electrical equipment will be grounded in accordance with NEC section 250.

6. Electric Steam Boiler to be Lattner Model #2080HS-480-32, 2080KW Cabinet Style Steam Boiler or equivalent. Boiler has two (2) power connection panels each with a 1600 amp Breaker c/w GFI and shunt trip. Each power panel has a load of 1250 amps @ 480vac.

7. Install Manual Motor Switch within 6 feet of Pump Motor P-301. Square D Part # 2510KW2H or equivalent.

U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

LATA Environmental Services of Kentucky, LLC

Environmental Resources Management
1218 3rd AVENUE, SEATTLE WASHINGTON
(425) 462-8591

McMillan-McGee Corp
CALGARY, ALBERTA CANADA
(403) 279-7948
FAX (403) 272-7201

DOE CONTRACT NO. DE-AC30-10CC40020

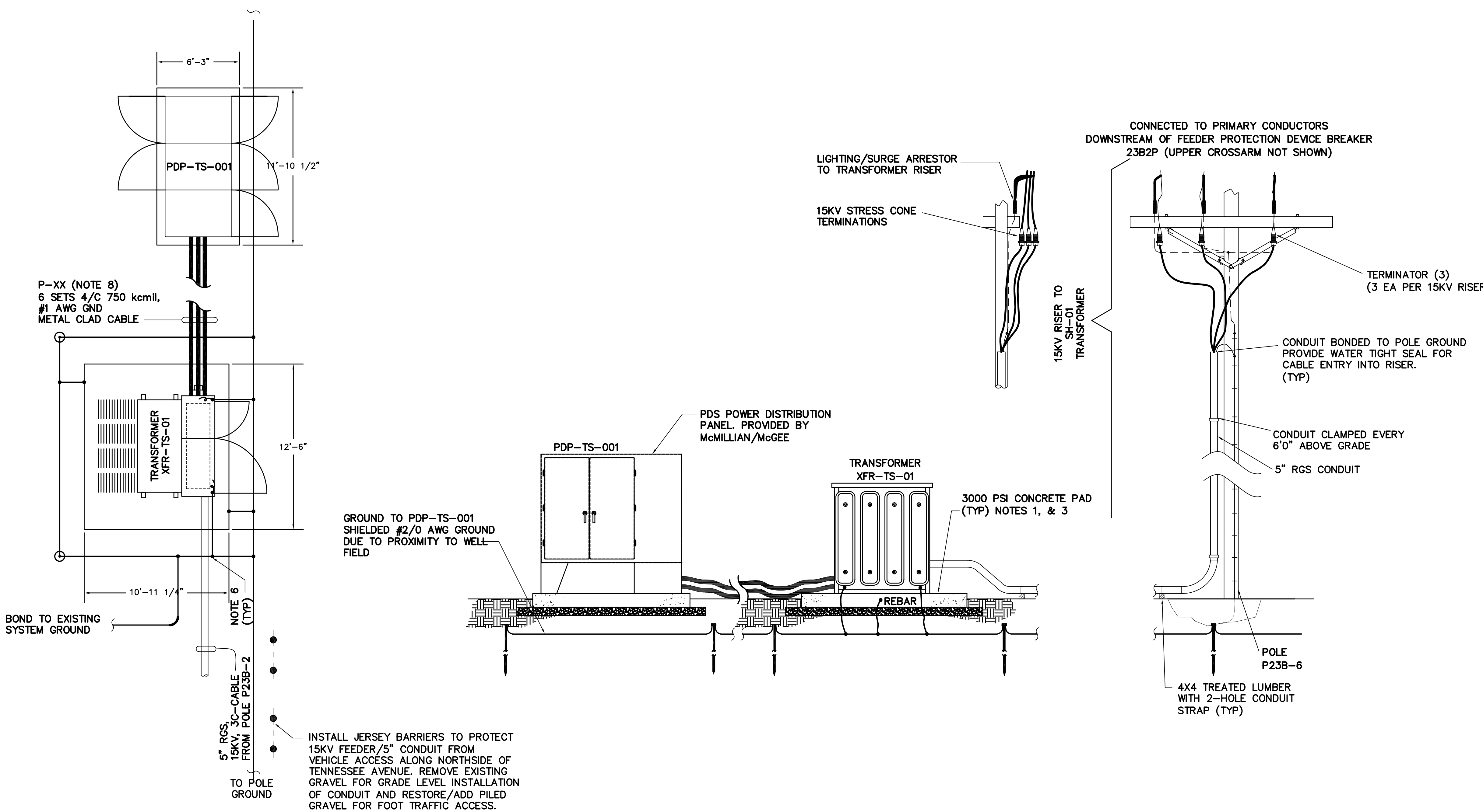
PROJECT NAME: C-400 STEAM INJECTION TREATABILITY STUDY

TITLE: TREATABILITY STUDY ELECTRICAL POWER ONE-LINE DIAGRAM

REV.	DATE	DESCRIPTION	DRAWN BY	DRAFT CHK	PROJ ENGR	LEAD ENGR
A	12/9/13	ISSUED FOR REVIEW	DP	ER	-	ER

CAD FILE NAME	BUILDING	PLANT	CLASS
A046_One-Line.dwg	C-400	PGDP	U

SCALE:	DRAWING NUMBER	REV
Not to Scale	E7DC40000A046	A



NOTES:

1. ALL EQUIPMENT ANCHOR BOLTS AND LOCATIONS TO BE PER MANUFACTURER RECOMMENDATIONS.
2. MAINTAIN A 5'-0" MINIMUM CLEARANCE AROUND SWITCHGEAR AND TRANSFORMER FROM ALL OTHER EQUIPMENT AND BUILDINGS.
3. ALL EMBEDDED STEEL AND WIRE MESH TO BE BONDED TO THE GROUNDING SYSTEM IN ACCORDANCE WITH NEC 250-81.
4. ALL BELOW GRADE GROUNDING CONNECTIONS SHALL BE MADE USING EXOTHERMIC WELDING TECHNIQUES.
5. TOPS OF DRIVEN GROUNDING ELECTRODES TO BE NO LESS THAN 1'-0" BELOW FINISHED GRADE SURFACE.
6. GROUND CABLES TO BE TERMINATED INSIDE EQUIPMENT PER MANUFACTURER'S INSTRUCTIONS.
7. GROUNDING SHALL COMPLY FULLY WITH ALL APPLICABLE REQUIREMENTS OF NFPA 70.
8. SEE DRAWING POWER ONE-LINE DIAGRAM FOR CABLE SIZES. SPECIAL CONSIDERATION TO BE TAKEN IN EQUIPMENT ORIENTATION DUE TO THE LARGE BEND RADIUS OF ARMORED CABLE & CONDUITS.

REV.	DATE	DESCRIPTION	DRAWN BY	DRAFT CHK	PROJ ENGR	LEAD ENGR	CONF CTRL/ NUCL SFTY	FAC MGR	ES&TS MGR
A	11/21/13	ISSUED FOR REVIEW	DP	ER	-	ER			

DRAWING REVISIONS

LPE

DATE

PROFESSIONAL SEAL

U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

LATA Environmental Services of Kentucky, LLC
managed for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC30-10CC40020 Paducah, Kentucky

Environmental Resources Management
1218 3rd AVENUE, SEATTLE WASHINGTON
(425) 462-8591

ERM

McMillan-McGee Corp
CALGARY, ALBERTA CANADA
(403) 279-7948
FAX (403) 272-7201

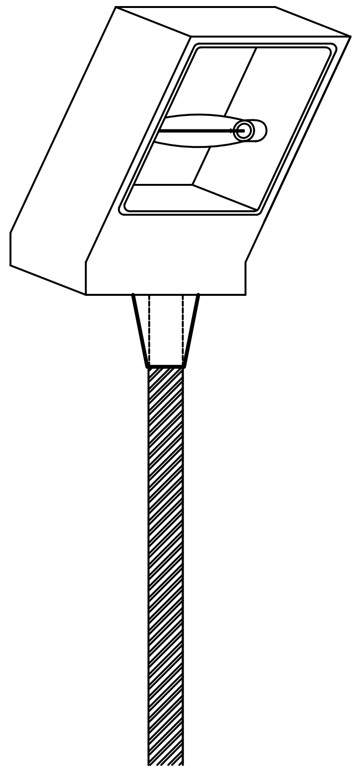
DOE CONTRACT NO. DE-AC30-10CC40020

PROJECT NAME:
C-400 STEAM INJECTION TREATABILITY STUDY

TITLE:
TREATABILITY STUDY ELECTRICAL POLE, TRANSFORMER & PDP DETAILS

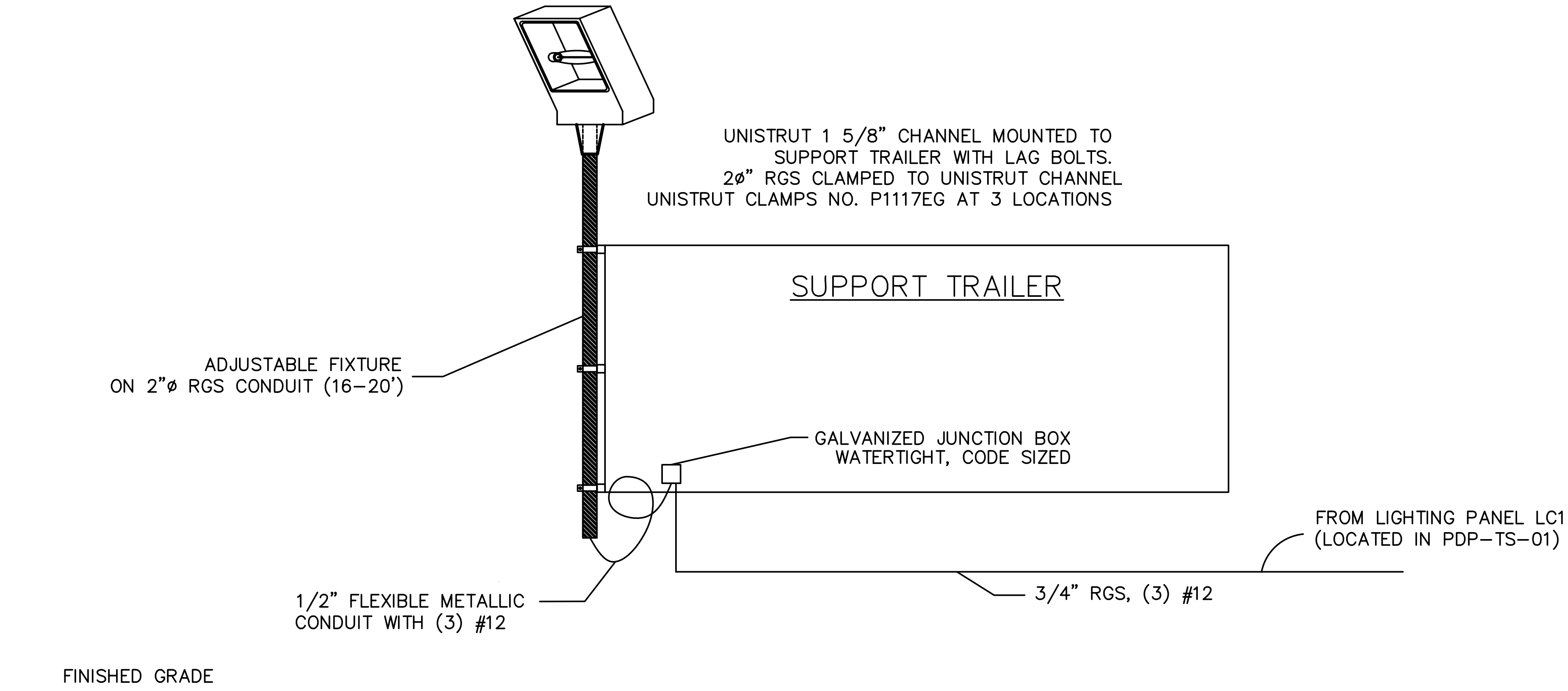
CAD FILE NAME	BUILDING	PLANT	CLASS
A047_Electrical Details.dwg	C-400	PGDP	U

SCALE:	DRAWING NUMBER	REV
Not to Scale	E7DC40000A047	A



2"Ø RGS POLE BRACKET

NTS



INSTALLATION OF FLOODLIGHT

NTS

NOTES:

1. 2"Ø RGS TO EXTEND ONE FOOT BELOW AND 6 FEET ABOVE SUPPORT TRAILER
2. CONSIDER FIXTURE TO WEIGH 44 POUNDS INCLUDING LAMP.
3. LIGHT FIXTURE ATTACHED WITH SLIP FITTING THAT SLIDES OVER 2" RGS CONDUIT

LIGHTING LAYOUT

NTS

1. LIGHT FIXTURE TO BE CONTROLLED BY PHOTO CELL INTEGRAL TO LIGHT. LIGHT FIXTURE FED FROM LIGHTING PANEL LC1 LOCATED IN PDP–TS–001

LIGHTING FIXTURE SCHEDULE

SYMBOL	LAMPS TYPE	LAMPS NO./FIXT.	TOTAL FIXT. WATTS	VOLTS	MANUFACTURER & CATALOG NO.	REMARKS
	MH	1/400W	465	120	GE FIXTURE NO. CFMX40E1A3MBLCKK 400W, MH, BLACK, INTEGRAL PE, 2 3/8" SLIPFITTER MOUNT	

U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

LATA Environmental Services of Kentucky, LLC
managed for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC30-10CC40020 Paducah, Kentucky

Environmental Resources Management
1218 3rd AVENUE, SEATTLE WASHINGTON
(425) 462-8591

McMillan–McGee Corp
CALGARY, ALBERTA CANADA
(403) 279–7948
FAX (403) 272–7201

DOE CONTRACT NO. DE-AC30-10CC40020

PROJECT NAME: C-400 STEAM INJECTION TREATABILITY STUDY

TITLE: TREATABILITY STUDY LIGHTING DETAILS

CAD FILE NAME	BUILDING	PLANT	CLASS
A048_Lighting Details.dwg	C-400	PGDP	U

SCALE:	DRAWING NUMBER	REV
Not to Scale	E7DC40000A048	A

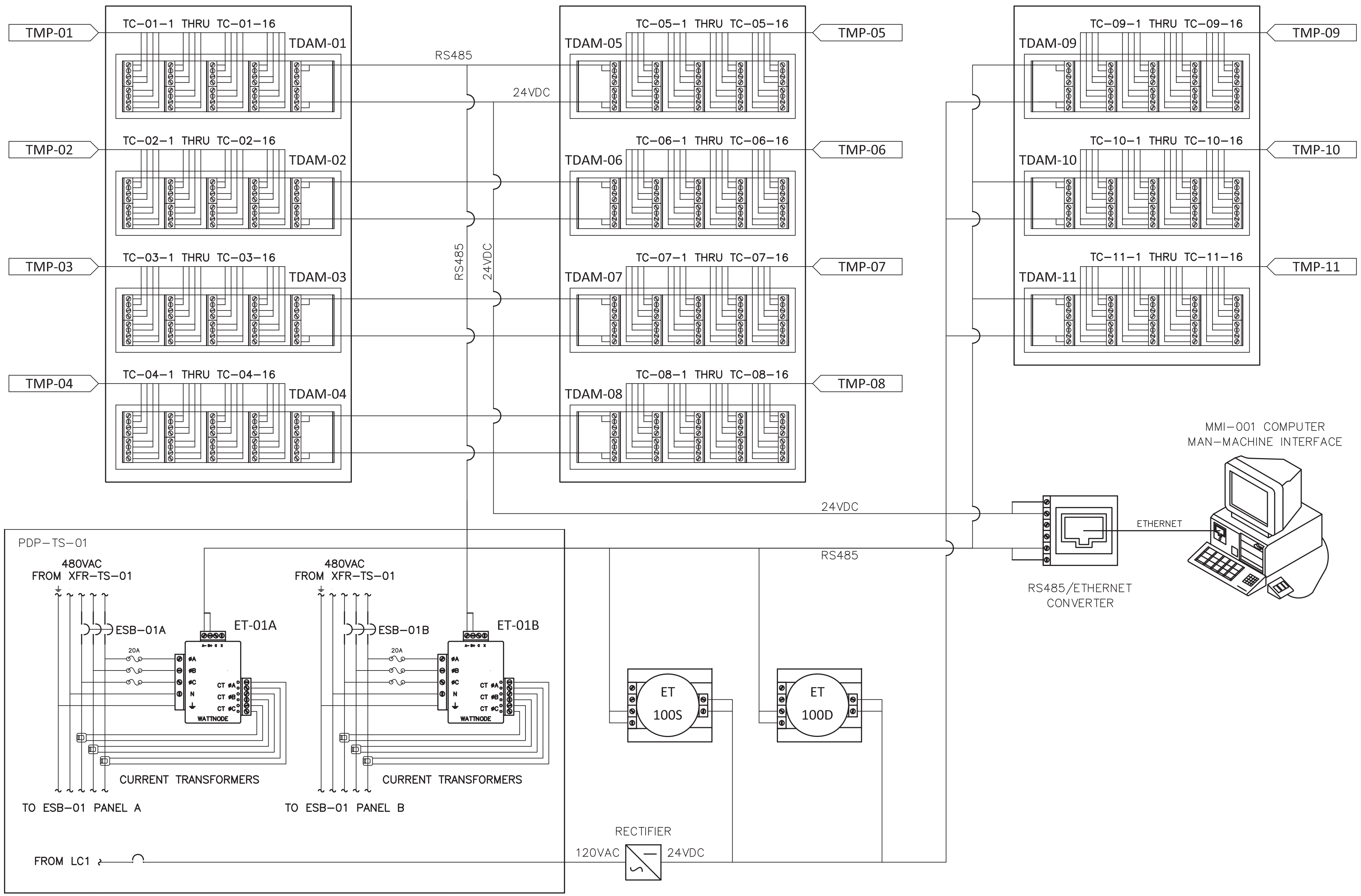
LPE

DATE

PROFESSIONAL SEAL

DRAWING REVISIONS

REV.	DATE	DESCRIPTION	DRAWN BY	DRAFT CHK	PROJ ENGR	LEAD ENGR	CONF CTRL/ NUCL SFTY	FAC MGR	E&TS MGR
A	12/9/13	ISSUED FOR REVIEW	DP	ER	–	ER			



NOTES:

1. TC DATA ACQUISITION MODULES CAN BE 8 CHANNEL OR 16 CHANNEL AND SHALL BE INSTALLED IN OUTDOOR RATED ENCLOSURES AT OR NEAR THE WELLHEADS.
2. RS485 AND 24VDC CONFIGURATIONS ARE DIAGRAMMATIC. ROUTING SHALL BE DETERMINED IN FIELD BASED ON FINAL EQUIPMENT LOCATIONS AND SUPPLIER REQUIREMENTS.
3. MULTIPLE CONDUCTORS ARE DEPICTED AS SINGLE LINES.
4. TC WIRING CAN BE COMBINED IN CONDUITS TO OPTIMIZE EFFICIENCY.
5. LOCATE RECTIFIER, CONVERTER, AND MMI–001 IN SUPPORT TRAILER.
6. ET–100S AND ET–100D SHALL PROVIDE THE FOLLOWING:
   - VOLUME FLOW — MASS FLOW
   - ENERGY FLOW — VELOCITY
   - TEMPERATURE — PRESSURE
   - DENSITY — VISCOSITY
   - ENTHALPY
7. ET–01A AND ET–01B SHALL PROVIDE THE FOLLOWING:
   - CURRENT — VOLTAGE
   - WATTS — WATT–HOURS

U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

LATA Environmental Services of Kentucky, LLC
managed for the DEPARTMENT OF ENERGY under U.S. GOVERNMENT contract DE-AC30-10CC40020 Paducah, Kentucky

ERM
Environmental Resources Management
1218 3rd AVENUE, SEATTLE WASHINGTON
(425) 462-8591

DOE CONTRACT NO. DE-AC30-10CC40020

PROJECT NAME:
C-400 STEAM INJECTION TREATABILITY STUDY

TITLE:
TREATABILITY STUDY
COMMUNICATIONS DIAGRAM

CAD FILE NAME	BUILDING	PLANT	CLASS
A049_COMM DIAGRAM.DWG	C-400	PGDP	U

SCALE:	DRAWING NUMBER	REV
AS SHOWN	E7DC40000A049	B

REV.	DATE	DESCRIPTION	DRAWN BY	DRAFT CHK	PROJ ENGR	LEAD ENGR	CONF CTRL/ NUCL SFTY	FAC MGR	E&TS MGR
B	2/3/14	ISSUED FOR REVIEW	JE	JE	CRE	CRE			
A	12/9/13	ISSUED FOR REVIEW	JE	JE	CRE	CRE			

DRAWING REVISIONS

LPE

DATE

PROFESSIONAL SEAL

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX B

SPECIFICATIONS

THIS PAGE INTENTIONALLY LEFT BLANK

SPECIFICATIONS FOR THERMAL REMEDIATION SYSTEM
C-400 STEAM INJECTION TREATABILITY STUDY

A		Issued for Review				
REV.	DATE	REASON FOR REVISION	ORIGINATOR	CHECKER	PROJECT ENGINEER	E&TS MGR

PROJECT SPECIFICATION	SPECIFICATION NO.: SPV-PHC400-P003
	SHEET 1 OF 162

THIS PAGE INTENTIONALLY LEFT BLANK

CONTENTS

MECHANICAL SPECIFICATIONS

ELECTRICAL SPECIFICATIONS

SECTION 02100 – SITE PREPARATIONS

PART 1 – GENERAL

1.1 DOCUMENTS

A. Exhibit A, General Conditions; Exhibit B, Special Conditions, Services; Exhibit C, Quantities, Prices, and Data; Exhibit D, Scope of Work; Exhibit F, Drawings; Exhibit G, Environmental, Safety, and Health Requirements; and Exhibit I, Submittals; and Exhibit J, Labor Standards/Labor Relations, apply to this section.

1.2 SUMMARY

A. This section covers work to prepare the site for construction of the treatability study thermal remediation system, including furnishing all equipment, tools, and labor necessary to execute the work.

1.3 SUBMITTALS

A. In accordance with Exhibit I.

B. SUBCONTRACTOR shall submit to the CONTRACTOR, within the construction work plan, a schedule delineating the intended sequence of this work with projected milestones, a traffic control plan, and a general description of how equipment, vehicles, and personnel decontamination procedures will be implemented. Include design to contain and collect equipment wash-down water. Personnel decontamination procedures shall also be outlined in the SUBCONTRACTOR health and safety plan.

1.4 DESIGN CRITERIA

A. Not Used.

1.5 QUALITY ASSURANCE

A. All materials, procedures, operations, and methods shall be in strict conformance with the drawings and specifications and shall be subjected to strict quality control monitoring, as detailed in these contract documents.

B. The SUBCONTRACTOR shall comply with all requirements of the U.S. Department of Energy and other local and regulatory agencies controlling environmental reviews and safety during the work.

1.6 SITE CONDITIONS

A. Protection of Persons and Property:

1. Install temporary chain link fencing or approved barricades around the work areas, as required, to control access and ensure Facility personnel safety. Coordinate with the CONTRACTOR for access to designated work areas and for authorizing areas to be released for work activities.
2. Erect and maintain temporary lights, barricades, signs, and other measures, as necessary, to protect the public, workers, and facility property from damage from construction work, in accordance with all applicable codes and regulations.
3. Barricade and post with warning lights at open holes and excavations occurring as part of the work when accessible through facility or through public access. Operate warning lights during hours from dusk to dawn each day and, as required by local regulations or the CONTRACTOR.
4. Protect adjacent sidewalks, utilities, pavements, and facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by the SUBCONTRACTOR construction operations.

B. Protection of Utilities:

1. Prior to site work, make arrangements for the protection of all underground and overhead utilities such as water, power, sewer, storm, fire, natural/liquid petroleum gas, electric, telephone, cable television, and other facilities that are conveyed through the facility which could come in contact with the SUBCONTRACTOR, in conformance with the requirements of the facility, Utility companies, or other local jurisdictions owning or controlling them. SUBCONTRACTOR shall arrange for an underground utility survey to be performed by a licensed professional prior to the start of any subsurface invasive work to locate and mark subsurface pipes, conduits, wires, structures, and other items that may be impacted
2. Notify, in writing, the site, utility companies, or other local jurisdictions concerned when any necessary disconnections, terminations, or reconnections are required. Perform the work in accordance with their standard practices and requirements and under their supervision, or make arrangements for the Work to be performed with their forces, if required.
3. Initiate and file all paperwork, obtain all permits, and pay all fees required to connect to and/or extend existing utilities.
4. Protect existing sewer and storm water discharges from construction activities. Unless otherwise specified, the SUBCONTRACTOR is not allowed to use existing discharges.

C. Control dust emissions in accordance with requirements of facility and local agencies.

D. Unknown Conditions:

1. The drawings and specifications may not represent all surface and subsurface features and conditions at the site and adjoining areas. The SUBCONTRACTOR shall verify the actual features and conditions to his satisfaction prior to start of work. The CONTRACTOR is not responsible for any items that should have been discovered as a result of this verification.
2. Locate exiting drainage and utilities.
3. Prepare drawings to depict all utilities for review by the CONTRACTOR a minimum of one week prior to start of work.

4. Protect existing utilities and drainage from damage. Any damage that is the direct result of SUBCONTRACTOR work shall be repaired at the sole expense of the SUBCONTRACTOR.

PART 2 – PRODUCTS

Not Used.

PART 3 - EXECUTION

3.1 SITE SETUP

A. Obtain all necessary permits and issue all applicable notifications prior to the start of work.

B. Install and maintain storm water control measures, as required by the CONTRACTOR and present working site conditions.

C. Install and maintain site security features, as necessary. Facility access shall be coordinated through the CONTRACTOR. Site security, including, but not limited to, all material, equipment, tools, and SUBCONTRACTOR property, shall be the sole responsibility of the SUBCONTRACTOR.

D. Install and maintain fuel, hazardous materials and waste storage, containment areas, and other staging areas, as required, to complete the work. An on-site area will be designated by the CONTRACTOR for use by the SUBCONTRACTOR to store materials, tools, equipment, office, and other items necessary for construction. The limits of the available storage and staging areas will be defined in the field by the CONTRACTOR. The SUBCONTRACTOR shall be fully responsible for the preparation of this area, its maintenance, and its security, including fencing, watchmen, or other means of security. Under no circumstances will the CONTRACTOR be responsible for the security of any property belonging to the SUBCONTRACTOR, its SUB-SUBCONTRACTOR, or any of its workforces.

E. Install and maintain temporary facilities and utilities, as required, to execute the work, including electrical, communication, sanitary, and waste disposal.

F. Install and maintain temporary waste storage areas. Relocate and reestablish, as required, to complete the work. The SUBCONTRACTOR shall be responsible for all waste characterization unless otherwise specified by the CONTRACTOR. Waste storage areas shall be determined by the CONTRACTOR prior to start of work. Any deviation from these areas by the SUBCONTRACTOR shall only be approved in writing by the CONTRACTOR.

G. Identify and protect (where required) all utilities at the site. The Contractor is responsible for repairing any and all damages at no additional cost.

H. Establish and maintain health and safety zones throughout the course of the work.

3.2 EQUIPMENT AND PERSONNEL DECONTAMINATION

A. The SUBCONTRACTOR shall establish decontamination area(s) for decontamination of all equipment and vehicles which contact site contaminants. The SUBCONTRACTOR shall insure that any equipment, vehicles, and personnel that have been in contact with site contaminants are properly decontaminated before leaving the work area. The SUBCONTRACTOR shall identify decontamination areas and procedures for personnel and equipment decontamination in the Work Plans per Section 01300 - Submittals.

B. The SUBCONTRACTOR may use brushing, vacuuming, steam cleaning, pressure washing, or equivalent methods for decontaminating vehicles and equipment. Steam cleaning may be required by the CONTRACTOR, depending on the equipment condition.

C. The SUBCONTRACTOR shall pay all costs related to decontamination of the SUBCONTRACTOR’S equipment and personnel, and any facility equipment, areas, and structures contaminated as part of the work, including disassembly, removal, and off-site disposal of the decontamination areas and spent personal protective equipment (PPE) established during the course of the work.

D. The SUBCONTRACTOR shall obtain all wash water needed for decontamination of equipment and personnel from a potable water source. Disposal of decontamination water shall be performed at the SUBCONTRACTOR’S expense.

3.3 PROGRESS CLEANING

A. The SUBCONTRACTOR shall maintain site in clean and orderly condition free of waste materials, debris, and rubbish. The SUBCONTRACTOR shall collect, transport, and dispose of all collected solid wastes generated from their operations in accordance with applicable solid waste disposal regulations at their own expense.

END OF SECTION

SECTION 02180 – STEAM INJECTION WELLS

PART 1 – GENERAL

1.1 DOCUMENTS

A. Exhibit A, General Conditions; Exhibit B, Special Conditions, Services; Exhibit C, Quantities, Prices. and Data; Exhibit D, Scope of Work; Exhibit E-Technical Specifications (Divisions 02 and 15); Exhibit F, Drawings; Exhibit G, Environmental, Safety, and Health Requirements; Exhibit I, Submittals; and Exhibit J, Labor Standards/Labor Relations, apply to this section.

1.2 SUMMARY

A. This section includes all equipment, labor, and materials necessary to install steam injection wells (SIW) as shown on the Drawings, including but not limited to, installation and sampling, construction materials, drilling, installation of well vault, decontamination, and waste characterization and disposal.

B. Related Sections include the following:
1. Division 01 – General Requirements
2. Division 02 – Site Construction
3. Division 15 – Mechanical

1.3 SUBMITTALS

A. In accordance with Exhibit I.

B. Well Permits: The SUBCONTRACTOR shall obtain and submit all copies of well permits obtained through local jurisdictions to the CONTRACTOR prior to mobilization to the Site.

C. Construction Work Plan: SUBCONTRACTOR shall include well installation details, methods and means, well development procedures, well performance testing, containment, decontamination, waste control and characterization, sampling, and monitoring.

D. SUBCONTRACTOR shall submit proof of drilling license to perform work covered by this Section.

E. SUBCONTRACTOR shall submit all material data sheets and certification that grout meets high temperature requirements (API Class G or CONTRACTOR-approved equal).

1.4 QUALIFICATIONS

A. Drilling firm performing the Work shall have adequate experience in steam injection well installation, as determined by the CONTRACTOR, and shall be trained, licensed, and qualified to perform the work unless otherwise approved in writing by the CONTRACTOR.

1.5 QUALITY ASSURANCE

A. The SUBCONTRACTOR shall perform work in accordance with all contract documents and any other information provided by the CONTRACTOR.
   1. The SUBCONTRACTOR shall document actual locations, depths, subsoil strata, groundwater elevation, drilling difficulties, and observed contamination encountered during the work.
   2. The SUBCONTRACTOR shall submit copies of all driller's documentation and logs generated during the course of the work.

PART 2 - PRODUCTS

2.1 GENERAL

A. Material requirements are specified on the drawings. Any deviation from these materials shall only be allowed for use by the SUBCONTRACTOR if approved in writing by the CONTRACTOR.

B. Filter pack sand gradation parameters are as follows:

Product		#2/12	#30
Nominal Sieve Size		12 x 20	30 x 70
US	**mm**	**Cumulative Percent Passing**	
3/8"	9.52	---	---
#3	6.70	---	---
1/4"	6.35	---	---
#4	4.75	---	---
#6	3.35	---	---
#8	2.36	100 ± 0	---
#12	1.70	96 ± 3	---
#16	1.18	20 ± 8	---
#20	0.850	1 ± 1	100 ± 0
#30	0.600	1 ± 1	95 ± 5
#40	0.425	---	73 ± 23
#50	0.300	---	25 ± 11
#70	0.212	---	3 ± 2
#100	0.150	---	1 ± 1

PART 3 - EXECUTION

3.1 PREPARATION

A. Survey all well locations +/- 0.1 foot or 3 centimeter (cm) laterally and 0.01 foot or 0.30 cm vertically.

B. Perform subsurface surveys and utility locates prior to start of work.

C. Protect all existing building features near the well location from damage. Any damage to building features resulting in the SUBCONTRACTOR performing the work shall be repaired immediately at the sole expense of the SUBCONTRACTOR. The SUBCONTRACTOR shall stop work and immediately notify the CONTRACTOR of any damage to the building features resulting from drilling activities.

D. Coordinate drill schedule with the CONTRACTOR to ensure ongoing facility operations are not impacted. CONTRACTOR approval is required before commencing work.

E. Provide metal plates to temporarily cover open borehole, as needed, to support ongoing facility operations at the end of each day.

F. The SUBCONTRACTOR shall be aware that there is the potential for blow outs of gases/liquids under pressure at sites where thermal operations have been conducted. The SUBCONTRACTOR shall take all applicable precautions during well installation and wellhead completion to safely contain, mitigate, decontaminate, and dispose of any subsurface materials that may be expelled as a result of drilling activities.

3.2 DRILLING

A. The SUBCONTRACTOR shall provide all equipment and material, as required, to execute the work.

B. The steam injection wellbore will include two (2) steam injection wells and one (1) temperature monitoring point per the drawings and specifications.

C. Saw-cut and removed concrete at drilling location.

D. Hand dig to 1.5 meters at the steam well location prior to drilling with mechanized equipment. Mechanized equipment can be used after 1.5 meters, unless other subsurface hazards are identified that may be impacted.

E. Water may be added during drilling only upon written approval by the CONTRACTOR.

F. Install two (2) SIWs in the boring as per drawings and specifications.

G. Install one (1) set of temperature sensors along the outside wall of the wellbore and complete as per drawings and specifications:
1. Maximum wire length shall not exceed 150 ft.
2. Wire splicing is not allowed.
3. Properly label all temperature sensor wires at several aboveground locations and at terminations for subsequent identification.
4. Tape the temperature sensor wiring at proper depth dimension per the Drawings to nonconductive material such as wood rod or equivalent and insert into borehole.
5. Coil and tape wiring at wellhead.
6. Protect wellhead wiring and fill casing/borehole with high temperature grout (API Class G or equivalent) to the wellhead vault.
7. Complete well installation as shown on the drawings.

H. Record depth to the top of installed seal with reference to land surface at the well location, and submit as inclusion to as-built drawings. In addition, the SUBCONTRACTOR shall record the manufacturer and quantities of material used for each fill or seal for each well installed.

I. Sand filter pack shall be installed using a tremie pipe or other methods approved by the CONTRACTOR. The sand filter pack shall be poured into the annulus to avoid bridging.

J. All drilling equipment and tanks and bins used for containment of drilling fluids and soil cuttings generated during drilling activities shall be decontaminated prior to arrival/departure to/from site, in conformance with Section 02100 – Site Preparations. The SUBCONTRACTOR shall decontaminate drilling equipment between well locations to the satisfaction of the CONTRACTOR.
1. The SUBCONTRACTOR shall containerize all drill cuttings in a roll-off bin or similar storage container approved by the CONTRACTOR.
2. The SUBCONTRACTOR shall containerize all fluids generated during the well installation activities. Fluids shall be stored in a water tight container or tank with lid approved by the CONTRACTOR.
3. The SUBCONTRACTOR shall characterize and arrange for proper disposal of all wastes generated during the work.

3.3 WELL DEVELOPMENT

A. Following installation, SUBCONTRACTOR shall develop all wells by:
1. Mechanically surging with surge block and pumping with a submersible pump, and/or
2. Airlift surging and pumping with compressed air.

B. Remove at least 10 well volumes, or until visibly clear water is discharged during the active (surging) portion of the development process, and:
1. Field-measured water quality, including temperature (± 1°C), pH (± 0.1 unit), and conductivity (± 3%) of the discharged water, has stabilized for three consecutive readings five (5) minutes apart, and
2. The turbidity is reduced to less than 10 nephelometric turbidity units (NTUs).

3.4 WELL VAULTS

A. Perform excavation for vault, and level and compact foundation, if necessary. The SUBCONTRACTOR shall follow all requirements of these specifications while performing excavation, including waste handling and off-site disposal.

B. Place vault as shown on the drawings and per manufacturer requirements.

C. Survey top of vault wall. Walls shall be level with no more than 0.25 in or 0.65 cm between any corners of the vault.

D. Set well vaults in place with concrete as shown on the drawings to match existing grade elevation and properly mark for subsequent identification.

3.5 CLEANING AND SURVEY

A. Clean work area, regrout if necessary.

B. The SUBCONTRACTOR shall be responsible for surveying the well installed.
   1. A qualified and licensed surveyor approved by the CONTRACTOR shall perform the work.
   2. Wells shall be surveyed both horizontally and vertically.
   3. The location of the top of the well casing shall be surveyed to the nearest +/- 0.01 ft or +/-0.3 cm vertically and +/- 0.1 foot or +/- 3 cm horizontally.

END OF SECTION

SECTION 02181 – TEMPERATURE MONITORING POINTS (TMP)

PART 1 – GENERAL

1.1 DOCUMENTS

A. Exhibit A, General Conditions; Exhibit B, Special Conditions, Services; Exhibit C, Quantities, Prices, and Data; Exhibit D, Scope of Work; Exhibit F, Drawings; Exhibit G, Environmental, Safety and Health Requirements; and Exhibit I, Submittals; and Exhibit J, Labor Standards/Labor Relations, apply to this section.

1.2 SUMMARY

A. This section includes all equipment, labor, and materials necessary to install temperature monitoring point, as shown on the drawings, including but not limited to, installation, construction materials, drilling, installation of well vault, decontamination, and waste characterization and disposal.

B. Related sections include the following:
1. Division 02 – Site Construction
2. Division 26 – Electrical.

1.3 SUBMITTALS

A. In accordance with Exhibit I.

B. Well Permits: The SUBCONTRACTOR shall obtain and submit all copies of well permits obtained through local jurisdictions to the CONTRACTOR prior to mobilization to the site.

C. Construction Work Plan: The SUBCONTRACTOR shall include well installation details, methods and means, well development procedures, well performance testing, containment, decontamination, waste control and characterization, sampling, and monitoring.

D. The SUBCONTRACTOR shall submit proof of drilling license to perform work covered by this section.

E. The SUBCONTRACTOR shall submit all material data sheets and certification that grout meets high temperature requirements (API Class G or CONTRACTOR-approved equal).

1.4 QUALIFICATIONS

A. Drilling firm performing the work shall have adequate experience in temperature monitoring point installation and shall be trained, licensed, and qualified to perform the work as determined by the CONTRACTOR.

1.5 QUALITY ASSURANCE

A. The SUBCONTRACTOR shall perform work in accordance with all Contract documents and any other information provided by the CONTRACTOR.

1. The SUBCONTRACTOR shall document actual locations, depths, subsoil strata, groundwater elevation, drilling difficulties, and observed contamination encountered during the work. Surveyed locations shall be provided to the CONTRACTOR as part of as-builts required under Section 01300 – Submittals.
2. The SUBCONTRACTOR shall submit copies of all driller's documentation and logs generated during the course of the work.

PART 2 - PRODUCTS

2.1 GENERAL

A. Material requirements are specified on the drawings. Any deviation from these materials shall only be allowed for use by the SUBCONTRACTOR if approved in writing by the CONTRACTOR.

PART 3 - EXECUTION

3.1 PREPARATION

A. Survey all temperature monitoring point locations +/- 0.1 ft or 3 centimeters (cm) laterally and 0.01 ft or 0.30 cm vertically.

B. Perform subsurface surveys and utility locates prior to start of work.

C. Protect all existing building features near the temperature monitoring point location from damage. Any damage to building features as a result of the SUBCONTRACTOR performing the work shall be repaired immediately at the sole expense of the SUBCONTRACTOR. The SUBCONTRACTOR shall stop work and immediately notify the CONTRACTOR of any damage to the building features resulting from drilling activities.

D. Coordinate the drilling schedule with the CONTRACTOR to ensure ongoing Facility operations are not impacted. CONTRACTOR approval is required before commencing work.

E. Provide metal plates to temporarily cover open boreholes, as needed, to support ongoing Facility operations and at the end of each day.

F. The SUBCONTRACTOR shall be aware that there is the potential for blow outs of gases/liquids under pressure at sites where thermal operations have been conducted. The SUBCONTRACTOR shall take all applicable precautions during temperature monitoring point installation and well-head completion to safely contain, mitigate, decontaminate, and dispose any subsurface materials that may be expelled as a result of drilling activities.

3.2 DRILLING

A. The SUBCONTRACTOR shall provide all equipment and materials as required to execute the work.

B. Ten (10) of the eleven (11) temperature monitoring points will be installed in new wellbores. One TMP will be installed in the steam injection wellbore per Section 02180 – Seam Injection Wells.

C. For 10 new temperature monitoring points, saw-cut and remove concrete at each drilling location.

D. Hand dig at each new temperature monitoring point location to 1.5 meters prior to drilling with mechanized equipment. Mechanized equipment can be used after 1.5 meters unless other subsurface hazards are identified that may be impacted.

E. Water may be added during drilling only upon written approval by the CONTRACTOR.

F. Install temperature sensors and complete boring as per drawings and specifications.
   1. Maximum wire length shall not exceed 150 ft.
   2. Wire splicing is not allowed.
   3. Properly label all temperature sensor wires at several aboveground locations and at terminations for subsequent identification.
   4. Tape wiring at proper depth dimension to non-conductive material such as wood rod and insert into borehole.
   5. Coil and tape wiring at wellhead.
   6. Protect wellhead wiring and fill casing/borehole with high temperature grout (API Class G or equivalent) to the wellhead vault.
   7. Complete well installation as shown on the drawings.

G. All drilling equipment and tanks and bins used for containment of drilling fluids and soil cuttings generated during drilling activities shall be decontaminated prior to arrival/departure to/from the site in conformance with Section 02100 – Site Preparations. The SUBCONTRACTOR shall decontaminate drilling equipment between well locations to the satisfaction of the CONTRACTOR.
   1. The SUBCONTRACTOR shall containerize all drill cuttings in a roll-off bin or similar storage container approved by the CONTRACTOR.
   2. The SUBCONTRACTOR shall containerize all fluids generated during the well installation activities. Fluids shall be stored in a water tight container or tank with lid approved by the CONTRACTOR.
   3. The SUBCONTRACTOR shall characterize and arrange for proper disposal of all wastes generated during the work.

3.3 WELL VAULTS

A. Perform excavation for vault, level and compact foundation if necessary. The SUBCONTRACTOR shall follow all requirements of these specifications while performing excavation, including waste handling and off-site disposal.

B. Place vault as shown on the drawings and per manufacturer requirements.

C. Survey top of vault wall. Walls shall be level with no more than 0.25 in or 0.65 cm between any corners of the vault.

D. Set well vaults in place with concrete as shown on the drawings to match existing grade elevation and properly mark for subsequent identification.

E. Perform connection to Temperature Data Acquisition Modules per Divisions 13, Special Construction, and 26, Electrical.

3.4 CLEANING AND SURVEY

A. Clean work area, re-grout if necessary.

B. The SUBCONTRACTOR shall be responsible for surveying the temperature monitoring points.

1. A qualified and licensed surveyor, approved by the CONTRACTOR, shall perform the work.
2. Wells shall be surveyed both horizontally and vertically.
3. The location of the top of the well casing shall be surveyed to the nearest +/- 0.01 ft or +/- 0.3 cm vertically and +/- 0.1 ft or +/- 3 cm horizontally.

END OF SECTION

SECTION 13420 – INSTRUMENTS AND CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Exhibit A, General Conditions; Exhibit B, Special Conditions, Services; Exhibit C, Quantities, Prices and Data; Exhibit D, Scope of Work; Exhibit F, Drawings; Exhibit G, Environmental, Safety and Health Requirements; Exhibit I, Submittals; and Exhibit J, Labor Standards/Labor Relations, apply to this section.

1.2 SUMMARY

A. This section includes the following instrumentation:
1. Gauges
2. Transmitters
3. Indicators

B. Related Sections include the following:
1. Division 15 – Mechanical
2. Division 26 – Electrical

1.3 SUBMITTALS

A. Submittals shall be provided as required by the contract documents. Unless otherwise stated, the SUBCONTRACTOR shall submit three hard bound copies and one electronic copy of each item a minimum of two weeks prior to procurement for CONTRACTOR approval. Items installed without CONTRACTOR approval are at the SUBCONTRACTOR’S risk and, if disapproved, shall be replaced at no additional cost. All submittals shall have an identification number for referencing. Faxes are not allowed.

B. Product Data: For each type of product indicated; include performance curves.

C. Shop Drawings: Schedule for instruments, meters, gauges, and transmitters indicating manufacturer’s number, scale range, tag number, and location for each.

D. Product Certificates for each type of instrument, meter, gauge, and transmitter, signed by product manufacturer.

E. Calibration Certificates for each type of meter, gauge, and transmitter, signed by vendor. All test instruments shall have identifying serial numbers, calibrations, and due dates indicated.

F. Installation, Operation, and Maintenance Data for each instrument, meter, gauges, and transmitter include operation and maintenance manuals.

G. Installation instructions, dimensions, and requirements

H. Consumable List and associated Material Data Safety Sheets (MSDSs)

I. Other items as specified within the drawings and specifications.

1.4 QUALITY ASSURANCE

A. Electrical Characteristics: Equipment of same electrical characteristics shall be furnished as specified in the drawings and specifications. If equipment of same electrical characteristics cannot be furnished, the SUBCONTRACTOR shall submit in writing the proposed alternate equipment, and identify the impact on electrical services, circuit breakers, conduit sizes, and associated structures. Such proposed alternates shall not be installed without written CONTRACTOR approval.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
   2. If no manufacturer is specified, the SUBCONTRACTOR shall propose a make and model that meets the minimum requirements as stated in the specifications and drawings.
   3. All instruments and scaling shall be approved by the CONTRACTOR.

2.2 BIMETALLIC-ACTUATED DIAL THERMOMETERS

A. Manufacturers:
   1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
   2. Ernst Gage Co.
   3. Noshok, Inc.
   4. Tel-Tru Manufacturing Company
   5. Trerice, H. O. Co.
   6. CONTRACTOR-approved equal

B. Description: Direct-mounting, bimetallic-actuated dial thermometers complying with ASME B40.3

C. Case: Dry type, stainless steel with 3-inch diameter minimum

D. Element: Bimetal coil

E. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings

F. Pointer: Red or other dark-color metal

G. Window: Glass

H. Ring: Stainless steel

I. Connector: Adjustable angle, rigid, back, or rigid, bottom, depending on location (must be readily viewable from ground level), ½-inch NPT

J. Stem: Metal for thermowell installation and of length to suit installation

K. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range

L. Outdoor installation

M. Temperature ranges: Unless otherwise specified:
1. Steam: 60°F to 500°F, with 2-degree scale divisions
2. Process Water: 30°F to 200°F, with 2-degree scale divisions
3. Blowdown Water: 30°F to 300°F, with 2-degree scale divisions

N. Make and Model: Not specified; subject to CONTRACTOR approval.

2.3 THERMOCOUPLES

A. Tag Numbers: TMP-1 through TMP-11, each strand consisting of a maximum 16 thermocouples at depth intervals specified in the specifications and the drawings.

B. Manufacturers:
1. Technical Industrial Products (TIP)
2. Omega Engineering
3. CONTRACTOR-approved equal

C. Description:
1. Type K thermocouple
2. Teflon insulation
3. Output signals will be sent to the Man-Machine Interface computer (MMI-01) via the Temperature Data Acquisition Modules.

D. Other Requirements:
1. Each temperature monitoring point (TMP-1 through TMP-11) shall have its thermocouple wiring strands terminated within a NEMA-4 enclosure that includes a Data Acquisition Module (TDAM).
2. Each thermocouple shall be labeled according to location and depth in the strand, and landed uniformly across all monitoring stations (i.e., depth 1 is channel 1, depth 2 is channel 2 across all monitoring stations up to depth 16 is channel 16).

E. Make and Model: Not specified; subject to CONTRACTOR approval.

F. Operation, Maintenance, and Installation Instructions: Include complete instructions.

2.4 TEMPERATURE DATA ACQUISITION MODULES

A. Tag Numbers: TDAM-01 through TDAM-11

B. Manufacturers:
   1. ICP DAS USA, Inc.
   2. Omega Engineering
   3. CONTRACTOR-approved equal

C. Description:
   1. Each TDAM module shall be 8 or 16 channels set for Type K thermocouples. The modules shall communicate with the Man-Machine Interface computer (MMI-01) using an RS-485 Modbus output and an Ethernet converter. MMI-01 shall have software to receive, process, record, trend, and archive the temperature data at various time intervals.
   2. Each module shall be installed on a backplate or DIN rail inside NEMA 4X rated enclosures. The enclosures shall be rated for temperatures up to 120°F. Include dessicant pack in each enclosure (minimum 113 g) fitted for moisture adsorption.
   3. Supply each enclosure with a 4-wire shielded cable (with drain wire) with a minimum AWG size of 18. Thermocouple strands entering each enclosure shall use cord grip inlets that area cinched per recommended torques to minimize ambient humidity from entering.
   4. Supply signal boosters, terminal resistors, and components as needed to ensure proper transmission of signals from thermocouples to MMI-01.
   5. Wire each TMP in series from TMP-to-TMP, allowing continuous flow of 24VDC and RS485 Modbus communication. Supply terminal resistors as needed.
   6. Each TMP shall have a unique Modbus node address.

D. Make and Model:
   1. TDAM – ICP DAS USA Model M-7018 (8 channel, quantity = 20)
   2. RS485 Serial-to-Ethernet converter – ICP DAS USA Model tDS-715 (quantity = 1)
   3. CONTRACTOR-approved equal

E. Operation, Maintenance, and Installation Instructions: Include complete instructions with TDAM Modules

2.5 PRESSURE GAUGES

A. Manufacturers:
   1. AMETEK, Inc.; U.S. Gauge Div.
   2. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
   3. Ernst Gage Co.
   4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
   5. WIKA Instrument Corporation
   6. CONTRACTOR-approved equal

B. Direct-Mounting, Dial-Type Pressure Gauges: Indicating-dial type complying with ASME B40.100.
   1. Case: Liquid-filled (glycerin) type, stainless steel, 2-1/2 inch diameter minimum.
   2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.

3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is required for viewing. For steam system, material shall be suitable for Class 150.
4. Movement: Mechanical, with link to pressure element and connection to pointer
5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings
6. Pointer: Red or other dark-color metal
7. Window: Glass
8. Ring: Stainless steel
9. Accuracy: Grade A, plus or minus 1 percent of middle half scale
10. Readings: US units (primary) with metric units (background)
11. Range for Fluids under Pressure: Two times operating pressure
12. Rated for outdoor installation

C. Pressure Gauge and Transmitter Fittings:
1. Valves: NPS 1/4 steel gate for Class 150 steam service.
2. Siphons: For steam system, NPS 1/4 coil of stainless steel tubing with threaded ends; include coupler rated for applicable steam conditions

D. Make and Model: Not specified; subject to CONTRACTOR approval

E. Operation, Maintenance, and Installation Instructions: Include complete instructions with gauge

2.6 STEAM ENERGY METER

A. Tag Nos.: ET-100S and ET-100D.

B. Manufacturers:
1. Endress+Hauser
2. Sparling Instruments, Inc.
3. CONTRACTOR-approved equal

C. Description: Vortex-shedding type. Media is Class 150 saturated steam.

D. Construction:
1. Stainless steel body
2. Class 150 flanged ends
3. Integral NEMA 4 transmitter for outdoor installation
4. Components rated for 150 psig saturated steam
5. Maximum pressure drop less than 3 psid at 3,000 pph with 100 psig inlet
6. UL Listed

E. Pressure Rating (minimum): 150 psig

F. Flow Rate Range (minimums): 500 to 3,000 pounds per hour (PPH)

G. Transmitter: Integral with flow meter, suitable for outdoor environments
1. Flow Rate Scale: Scaled in PPH
2. Accuracy: Plus or minus 2 percent maximum
3. Local display
4. RS485 output to MMI-01 via RS485/Ethernet serial converter

5. Loop powered (24 vdc). Provide all power, transformers, inverters, etc., to power instrument.
6. Provide the following output signals:
   a. Volumetric Flow Rate
   b. Mass Flow Rate
   c. Energy Flow Rate
   d. Temperature
   e. Pressure
   f. Density
   g. Totalized Flow
7. Record at 30-minute intervals (minimum)

H. Make and Model:
   1. Spirax Sarco model VLM10-050-3AB-6-D3-A-0
   2. CONTRACTOR-approved equal

I. Operation, Maintenance, and Installation Instructions: Include complete instructions with flow meter

2.7 ELECTRICAL ENERGY METER

A. Tag Nos.: ET-01A through ET-01F

B. Manufacturers:
   1. Continental Control System
   2. CONTRACTOR-approved equal

C. Description: Network energy meter to measure watts, voltage, and current, receive input from current transformers on each phase (A, B, and C). Install eight (8) total on parallel runs from main transformer XFR-TS-01 to power distribution panel PDP-TS-001.

D. Construction:
   1. Remote meters connected to line voltage via current transformers
   2. Requires no external electrical power
   3. Full-scale accuracy less than 1 percent
   4. UL Listed
   5. Install inside PDP-TS-001

E. Electrical Rating:
   1. Meter – 480 vac line-to-line, 3 phase, 60 hertz
   2. Current Transformers: three per meter (one per phase), rated for 1,200 amps per phase; total number is 24 for the eight (8) parallel runs from main transformer XFR-TS-01 to power distribution panel PDP-TS-001

F. Temperature Rating: 30°F to 130°F

G. Make and Model:
   1. Continental Control System Model WNC-3Y-480-MB with CTS-2000 current transformers
   2. CONTRACTOR-approved equal

2.8 MAN-MACHINE INTERFACE COMPUTER

A. Tag Nos.: MMI-01

B. Manufacturers:
   1. Dell
   2. HP
   3. CONTRACTOR-approved equal

C. Description: Computer to receive, display, record, and transmit instrumentation data.

D. Software: PC Modbus software for monitoring and configuring Modbus devices.

E. MODBUS Requirements:
   1. Two-wire plus shield and drain of 16AWG copper or aluminum wire shall be used.
   2. 19,200 bps, 8-bit, Even Parity, no Stop bit should be used for all MODBUS communications.

F. Ethernet Requirements:
   1. Category 5e minimum (CAT 6 preferred)
   2. 10/100 mbps data rate

G. Make and Model:
   1. Not specified; subject to CONTRACTOR-approval

H. Operating and Installation Instructions: Include complete instructions with software

PART 3 - EXECUTION

3.1 ENERGY METER APPLICATIONS

A. Install and wire meters, as shown on the drawings and as prescribed by manufacturers.

B. Configure MMI software.

3.2 PRESSURE GAUGE APPLICATIONS

A. Install liquid-filled-case-type pressure gauges as shown on the drawings.

3.3 INSTALLATIONS

A. Install direct-mounting pressure gauges in piping tees or threadolets with pressure gauge located on pipe at most readable position.

B. Install isolation valve in piping for each pressure gauge.

C. Install siphon fitting and isolation valve in piping for each pressure gauge for steam.

D. Install meters in accessible positions for easy viewing, in piping systems.

E. Assemble and install connections, tubing, and accessories between flow-measuring elements and flow meters, as prescribed by manufacturer’s written instructions. Furnish and install strainers, bypasses, and other items, as recommended by manufacturer.

F. Install flow meter elements in accessible positions in piping systems.

G. Install flow meter elements with at least 10 pipe diameters minimum upstream and 5 pipe diameters minimum downstream of straight lengths of pipe from element, or as prescribed by manufacturer's written instructions.

H. Install wafer/lug type flow meter elements between pipe flanges with same rating as pipe.

I. Install flow meters as shown on the drawings.

J. Install, program, test MMI-01 software system.

3.4 CONNECTIONS

A. Install meters and gauges adjacent to equipment to allow viewing, service, and maintenance.

B. Ensure equipment is properly grounded.

C. Connect wiring according to electrical requirements.

3.5 ADJUSTING

A. Verify meters calibrated according to manufacturer's written instructions, after installation.

B. Adjust faces of meters and gauges to proper angle for best visibility.

C. Cleaning: Clean windows of gauges and factory-finished surfaces. Replace cracked and broken windows.

3.6 WARRANTY

A. Provide minimum one year warranty on all equipment, parts, and labor.

END OF SECTION

SECTION 15000 - GENERAL REQUIREMENTS FOR MECHANICAL WORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Exhibit A, General Conditions; Exhibit B, Special Conditions, Services; Exhibit C, Quantities, Prices, and Data; Exhibit D, Scope of Work; Exhibit F, Drawings; Exhibit G, Environmental, Safety, and Health Requirements; and Exhibit I, Submittals; and Exhibit J, Labor Standards/Labor Relations, apply to this section.

B. Sections of other divisions relating to mechanical work apply to the work of this section.

1.2 SUMMARY

A. This section specifies the basic requirements for mechanical installations and includes requirements common to more than one section of Division 15.

B. Scope of Work – The scope of work performed under this contract shall consist of furnishing all labor and installation of all material, equipment, services, permits, fees, and appurtenances for the mechanical systems, as defined on the mechanical specifications and drawings.

1.3 DEFINITIONS

A. Definitions of terms used herein:

1. "Furnish" or "Provide": To furnish, erect, install, or connect complete and ready for regular operation.
2. "Work": All labor, material, equipment, apparatus, controls, accessories, and other items customarily furnished and/or required for proper and complete installation of work.
3. "Piping": Pipe, fittings, flanges, flange kits, valves, controls, tubing, supports, traps, drains, vents, insulation, and other items necessary or required, in connection with or relating to such piping to provide a complete installation.
4. "Concealed": Embedded in masonry, concrete, or buried.
5. "Exposed": Not installed underground or "concealed".
6. "Indicated" or "Shown": As indicated or shown on the drawings.
7. "Noted": As indicated and/or specified on the drawings.
8. "CONTRACTOR": Department of Energy, Paducah Gaseous Diffusion Plant.
9. "SUBCONTRACTOR": Entity responsible for the mechanical work, which shall perform the work in accordance with the design specifications, drawings, and contract documents.
10. "Specifications" and "Drawings": The documents that provide the requirements for the work. Because of the small scale of the drawings, it is not possible to indicate all offets, routes, interferences, fittings, and accessories. The SUBCONTRACTOR shall investigate and understand all existing conditions prior to starting work.

1.4 SUBMITTALS

A. Refer to the below list and the individual sections of Division 15 for submittal requirements. All documents shall be submitted in English.

B. Shop drawings, including fabrication, installation details, configuration layouts, dimensions, and elevations

C. Equipment weights (dry and flooded)

D. Material certificates

E. Warranty cards

F. Product data and cut sheets

G. Testing data and performance curves

H. Anchoring requirements

I. Storage requirements

J. Installation, operations, and maintenance manuals

K. Spare parts and consumable list

L. Record drawings, showing as-built conditions: During construction, maintain one extra set of black-line white print drawings for use as record drawings. Records shall be kept daily using red pencil. As the work is completed, relevant information shall be transferred to a reproducible set, and hard and electronic (AutoCAD) copies shall be given to the CONTRACTOR.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Equipment, materials, and accessories shall be installed in a workmanlike manner by skilled and experienced workers who regularly are engaged in this type of work.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Ship materials in containers marked by manufacturer with appropriate specification designation, type, and grade.

B. Storing: All equipment, materials, and accessories delivered to the jobsite shall be stored in a safe, dry place. Prevent end damage and dirt, water, and moisture from entering.

C. The SUBCONTRACTOR shall use whatever means necessary to protect the equipment, materials, and accessories before, during, and after installation. No equipment, materials, and accessories shall be installed that have been damaged in any way.

D. Equipment and materials shall be stored and handled per manufacturer recommendations, and shall be protected from weather at all times.

1.7 COORDINATION

A. Carefully review and examine specifications and drawings, existing site conditions, and facility operating schedules. Coordinate work with others to avoid delays. Be responsible to ensure work installed does not interfere with work of other SUBCONTRACTORS or facility personnel. If there is interference, the work shall be corrected at no additional costs.

B. Coordinate with installation of pipe supports, electrical conduits, heat tracing, and equipment. The locations, elevations, layouts, and distances as shown on the drawings are not exact. Installations shall allow maximum headroom and access, and shall not pose a tripping hazard.

C. Locate all utilities prior to performing the work, this includes overhead, subsurface, and embedded. Coordinate connections with the utility supplier and the CONTRACTOR at least two weeks prior to the anticipated tap-in date. Any damage to existing utilities shall be repaired to the satisfaction of the CONTRACTOR at no additional cost.

D. Coordinate work with the construction, tests, inspections, and facility schedules.

E. Unless otherwise specified, all equipment shall include motors, controls, and appurtenances, as required for proper operation.

1.8 CODES, RULES, AND REGULATIONS

A. The work shall be performed in strict accordance with application provisions of the various codes, ordinances, and standards pertaining to the project location. All material, labor, permits, and fees necessary to comply shall be provided. Where the specifications and/or drawings indicate materials or construction above the requirements, the specifications and drawings shall apply.

B. The rules, regulations, and ordinances of all applicable governing bodies in force at the time of this contract shall become a part of the specifications. These shall include local, precinct, federal, facility, and utility company requirements.

C. The SUBCONTRACTOR shall give all necessary notices, obtain all permits, and pay all governmental taxes, fees, deposits, and other costs in connection with the work. The SUBCONTRACTOR shall file all necessary plans, prepare all documents, and obtain all required approvals for the work.

1.9 QUALITY OF MATERIALS, EQUIPMENT, AND WORKMANSHIP

A. All equipment and material shall be the standard products of manufacturers regularly engaged in the production of similar components.

B. Where practical, all equipment and material shall be sourced locally, unless otherwise specified.

C. All personnel performing the work shall be skilled in the assigned work. Should the CONTRACTOR deem any worker to be incompetent, the SUBCONTRACTOR shall dismiss that person immediately.

D. All welders involved in welding pressure piping shall be certified in accordance with Section IX of the ASME Boiler and Pressure Vessel Code. Written verification shall be submitted prior to performing any work.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine existing site and facility conditions prior to commencing work. Notify the CONTRACTOR if there are any discrepancies or unsafe conditions.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry pipe, valve, and fitting surfaces. Remove materials that will adversely affect installation. Comply with manufacturer's written instructions.

B. Ensure that required pressure testing of piping and fittings has been completed prior to installing insulation.

3.3 GENERAL APPLICATION REQUIREMENTS

A. Install equipment to facilitate maintenance, repair, and replacement. As much as practical, connect equipment for ease of disconnecting, with minimal interferences with other installations. This includes using unions and flanges at equipment connections.

B. To the fullest extent permitted by laws and regulations, the SUBCONTRACTOR shall indemnify and hold harmless CONTRACTOR arising out of or relating to Hazardous Environmental Conditions created by the SUBCONTRACTOR, by anyone for whom SUBCONTRACTOR is responsible, or by CONTRACTOR.

C. The SUBCONTRACTOR shall supervise, inspect, and direct the work competently and efficiently, applying skills and expertise to perform the work in accordance with the contract documents. The SUBCONTRACTOR shall be solely responsible for the means, methods, techniques, sequences, scheduling, and procedures of construction.

D. The CONTRACTOR will be the initial interpreter of the requirements of the contract documents and judge the acceptability of the work. The CONTRACTOR will not be responsible for acts or omissions of the SUBCONTRACTOR or any SUB-SUBCONTRACTORS, suppliers, or any other individual or entity performing any of the work.

E. If laws or regulations of any public body or utility having jurisdiction require any of the work to be inspected, tested, or approved by that public body or utility, the SUBCONTRACTOR shall assume full responsibility for arranging and obtaining such inspections, tests, and approvals; pay all associated costs; and furnish the CONTRACTOR the required certificates. The CONTRACTOR shall be notified at least two weeks in advance of scheduled inspections and tests.

F. At all times during the progress of the work, the SUBCONTRACTOR shall provide and assume full responsibility for all services, materials, equipment, labor, transportation, construction equipment and machinery, tools, appliances, fuel, power, light, heat, air conditioning, telephone, internet, sanitary facilities, temporary facilities, and incidentals necessary for performance, testing, start-up, and completion of the work.

G. The SUBCONTRACTOR shall not perform any work that is contrary to the governing laws and regulations.

H. The SUBCONTRACTOR shall provide hangers and supports for all piping.

I. All equipment that may require adjustment, maintenance, repair, or replacement shall be readily accessible with at least 28 inches of walk-around space. CONTRACTOR approval is required for any deviations.

J. All grease fittings shall be extended to an accessible location.

K. Where building penetrations are required, the SUBCONTRACTOR shall furnish and install steel pipe sleeves with an annular space of at least 0.5 inches around the main pipe, and sufficient so as to not interfere with any expansion and contraction. Opening shall be sealed properly following installation to prevent water from entering the building.

L. The SUBCONTRACTOR shall store all materials and equipment in on-site laydown areas designated by the CONTRACTOR. If additional area is needed and none is available on-site, the SUBCONTRACTOR shall make arrangements at no additional costs for off-site location.

3.4 STRUCTURAL SUPPORTS

A. CONTRACTOR approval is required before work can proceed with the SUBCONTRACTOR’S proposed route and layout.

B. Unless otherwise indicated, the SUBCONTRACTOR shall provide all necessary miscellaneous steel required for installation of the work. This includes, but is not limited to, piping supports, equipment supports, anchoring, and bracing. The SUBCONTRACTOR shall perform all rigging to set the components in place.

C. Structural components shall be hot dip galvanized or finished with corrosion resistance coating, as approved by CONTRACTOR. All welds and cuts shall be painted with a cold galvanized or equivalent coating.

3.5 PIPING GENERALLY

A. All piping shall be installed so as to not interfere with any electric lighting, power, and communication cables and conduits, ductwork, or other piping and equipment. No piping shall pass in front of or interfere with any opening, door, or window. Headroom in front of such openings and doors shall not be less than the top of the opening.

B. The SUBCONTRACTOR shall not install piping with valves, joints, or fittings over any motor, transformer, electrical switchboard, or equipment.

C. The drawings generally are indicative of the work to be installed and do not indicate all offsets, bends, fittings, elevations, valves, traps, and similar parts, which may be specified or required. The SUBCONTRACTOR shall carefully investigate the existing conditions affecting the mechanical work and furnish the necessary parts.

D. Pipes shall be measured and cut accurately, and shall be installed with no springing or forcing. Changes in direction or reduction in size shall be made with standard fittings. No mitering of pipe to form elbows or reducers will be permitted. Before erection, all piping shall be thoroughly cleaned and, if necessary, after erection to remove any foreign matter.

E. All water and steam systems shall be installed in such a manner that they can be drained and vented completely. Provide manual air vents at high points and drain valves at low points.

F. All steam piping shall be installed with hoses sufficient to accommodate maximum thermal expansion.

G. Connections to existing utilities such as gas and water shall be coordinated with the CONTRACTOR and utility company. The SUBCONTRACTOR is responsible for obtaining permits and paying all associated fees.

H. The SUBCONTRACTOR shall follow all requirements for lockout and tagout, drawing, connecting, cleaning, and placing back in service.

3.6 CLEANUP

A. The SUBCONTRACTOR shall keep the site clean during the progress of the work. This includes cleaning up and broom sweeping throughout the day to prevent accumulation and storage of wastes and debris, or as directed by the CONTRACTOR.

B. The SUBCONTRACTOR shall remove all wastes, rubbish, packing material, crates, metal scraps, cut-offs, and debris at the end of the day and as necessary throughout the day.

C. Wastes shall be deposited in SUBCONTRACTOR-supplied containers in locations approved by the CONTRACTOR. The SUBCONTRACTOR is responsible for paying all haul and disposal fees.

D. After all equipment has been installed, the SUBCONTRACTOR shall remove and dispose of all stickers, rust stains, labels, tape, shipping materials, temporary covers, etc.

E. All foreign matter shall be blown out or flushed out of all piping, ducting, motors, devices, switchboards, panels, etc.

F. The SUBCONTRACTOR shall leave work at all times in a safe and clean condition ready for facility use.

END OF SECTION

SECTION 15050 - BASIC MECHANICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Exhibit A, General Conditions; Exhibit B, Special Conditions, Services; Exhibit C, Quantities, Prices, and Data; Exhibit D, Scope of Work; Exhibit F, Drawings; Exhibit G, Environmental, Safety, and Health Requirements; and Exhibit I, Submittals; and Exhibit J, Labor Standards/Labor Relations, apply to this section.

1.2 SUMMARY

A. This section includes the following:
- All major equipment and ancillary components
- Piping materials and installation instructions common to most piping systems
- Equipment installation requirements
- Painting and finishing
- General concrete bases
- Supports and anchorages, including wind and seismic restraint requirements

1.3 DEFINITIONS

A. Definitions of terms used herein:
1. "Furnish" or "Provide": To furnish, erect, install, or connect complete and ready for regular operation.
2. "Work": All labor, material, equipment, apparatus, controls, accessories, and other items customarily furnished and/or required for proper and complete installation of work.
3. "Piping": Pipe, fittings, flanges, flange kits, valves, controls, tubing, supports, traps, drains, vents, insulation, and other items necessary or required, in connection with or relating to such piping to provide a complete installation.
4. "Concealed": Embedded in masonry, concrete, or buried.
5. "Exposed": Not installed underground or "concealed."
6. "Indicated" or "Shown": As indicated or shown on the drawings.
7. "Noted": As indicated and/or specified on the drawings.

1.4 RELATED DRAWINGS

A. Drawing index

G7DC40000A001	COVER SHEET
C7DC40000A027	SITE PLAN
C7DC40000A028	STEAM INJECTION WELLS AND TEMPERATURE MONITORING POINTS
P7DC40000A058	SYMBOLS, IDENTIFICATION, ABBREVIATIONS, NOTES, AND REQUIREMENTS

P7DC40000A059	PROCESS FLOW DIAGRAM
P7DC40000A060	PIPING AND INSTRUMENTATION DIAGRAM (SHEET 1 OF 2)
P7DC40000A061	PIPING AND INSTRUMENTATION DIAGRAM (SHEET 2 OF 2)
P7DC40000A062	PIPING PLAN
P7DC40000A063	WELLHEAD AND PIPING DETAILS
E7DC40000A046	ELECTRICAL POWER ONE-LINE DIAGRAM
E7DC40000A047	ELECTRICAL POLE, TRANSFORMER, & PDP DETAILS
E7DC40000A048	LIGHTING DETAILS
E7DC40000A049	COMMUNICATIONS DIAGRAM

B. Drawings are generally diagrammatic and indicative of work to be installed. As such, fully dimensioned locations, offsets, and required fittings of various elements of the work may not be provided. The SUBCONTRACTOR shall determine the exact locations and requirements from field measurements with CONTRACTOR approval, which is considered a part of the work.

C. Consult drawings and specifications to determine number and requirements of all items of equipment requiring piping, such as vents, drains, reliefs, strainers, and traps wherever equipment is provided with connections for such.

D. Piping run and arrangement are indicated roughly and subject to modifications, as required to suit site conditions and avoid interferences.

E. Where dimensions are specified on the drawings, the installation shall be as indicated to maintain the validity of supporting calculations and analyses. If deviations from the specified dimensions are required, CONTRACTOR approval must first be obtained prior to installation.

F. Ensure equipment dimensions and layout fit in the project area with a 28 inch clearance minimum in walkways. Obtain CONTRACTOR approval for final locations prior to anchoring.

1.5 SUBMITTALS

A. Submittals shall be provided as required by the contract documents and Section 01300. Unless otherwise stated, the SUBCONTRACTOR shall submit three bound hard copies and one electronic copy (PDF) of each item a minimum of two weeks prior to procurement for CONTRACTOR approval. All submittals shall have an identification number for referencing. All pertinent and relevant information shall be clearly annotated using arrows, circles, or highlighting. Faxes are not allowed.

B. Product data for the following:

1. Valves
2. Fittings
3. Equipment
4. Instruments, including calibration certificates
5. Piping
6. Insulation
7. Supports
8. Accessories

C. Welding documentation and certificates (submit prior to welding):
1. Welder procedure qualification reports
2. Weld procedures and specifications
3. Weld radiographic inspection reports
4. Filler metal control procedure
5. List of names and identification symbols for qualified welders prior to welding
6. Any other documentation required by applicable American Society of Mechanical Engineers (ASME), CONTRACTOR'S, or AWS Codes.

D. All pump performance curves

E. Single line electrical drawings and wiring schematics

F. Installation instructions and drawings, including all connection requirements, dimensions, and support anchoring

G. Installation, operations, and maintenance manuals

H. Recommended spare parts and consumable lists with pricing for each item

I. Material Data Safety Sheets (MSDSs) for all consumables

J. ASME Pressure Vessel U-1/U-1A forms for pressure vessels

K. Noise levels (dBA) at 3 ft (1 meter) for all equipment and systems

L. Pump net positive suction head (NPSH) requirements

M. Other items as specified within the drawings and specifications

1.6 QUALITY ASSURANCE

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

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for Mechanical Equipment: Equipment of same electrical characteristics shall be furnished as specified in the drawings and specifications. If equipment of same electrical characteristics cannot be furnished, the SUBCONTRACTOR shall submit in writing the proposed alternate equipment and identify the impact on electrical services, circuit breakers, conduit sizes, and associated structures. Such proposed alternates shall not be installed without written CONTRACTOR approval.

D. Provide equipment, instruments, and control panels with nameplates identifying at minimum, the manufacturer's name, model number, serial number, and design rating capacity.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Provide services, labor, accessories, and equipment to properly offload and store materials and equipment.

B. After delivery, all materials and equipment shall be protected from anything that could cause damage to the material and equipment. Provide and perform manufacturer recommended measures for storage, including measures to protect from water and moisture intrusion.

C. Fittings shall be sorted and stored by system, and interior surfaces shall remain clean. Measures shall be taken to protect from water and moisture intrusion.

D. Insulation shall be kept dry and clean.

E. Pipes and tubes shall have factory-applied end caps through shipping, storage, and handling to prevent pipe end damage and entrance of dirt, debris, and moisture.

1.8 COORDINATION

A. Coordinate all work with the CONTRACTOR

B. Coordinate installation of conduit and cable tray on the pipe supports

C. Coordinate equipment delivery and offloads

D. Coordinate testing of piping, welds, equipment, civil, electrical, and controls

1.9 SERVICE ENVIRONMENT

A. All equipment shall be capable of operating in ambient temperatures from 0°F to 115°F and relative humidity up to 95 percent.

B. All equipment shall have a five-year service life minimum in outdoor environments.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to, the manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.
3. All electrical components shall meet requirements of UL or FM.

2.2 PIPE, TUBE, FITTINGS, AND VALVES

A. Refer to individual Division 15 piping sections for pipe, tube, fitting, and valve materials and joining methods.

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

2.3 JOINING MATERIALS

A. Refer to individual Division 15 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for thermal conditions of piping system contents.
   1. Steam and Blowdown Water System—ASME B16.20, metallic, spiral wound, asbestos-free, 1/8-inch thick, unless otherwise indicated or CONTRACTOR approved.
   2. Noncontaminated Liquid Systems—ethylene propylene diene monomer (EPDM) M-class rubber, flat face, 1/8-inch thick, unless otherwise indicated or CONTRACTOR approved.

C. Steel Pipe Flange Bolts and Nuts: ASTM A193 B7-HH and ASTM A194 2H-HH carbon steel, unless otherwise indicated or CONTRACTOR approved.

D. Solder Filler Metals: ASTM B32, lead-free alloys, include water-flushable flux according to ASTM B81.

E. Welding Filler Metals: Comply with ASME Boiler Pressure and Vessel Code per B31.3 and AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 SLEEVES

A. Steel Pipe: ASTM A53, Grade B, Schedule 40, galvanized, plain beveled ends

2.5 GROUT

A. Nonshrinking type; grout for wells shall be rated for high temperatures

2.6 STEAM PLANT

A. Tag No.:
   1. ESB-01: Electric Steam Boiler

B. Suppliers:
   1. Lattner
   2. Power Mechanical
   3. CONTRACTOR-approved equal

C. Description: Steam plant consisting of one packaged steam boiler installed to supply at least 6,000 lb/hr dry saturated steam at 140 psig to the two steam injection wells (SIW-01S and SIW-01D). The boiler will be sized to preclude the requirement to have an operator on-site during operation. The system will be skid-mounted and fully assembled (prewired and prepiped) and consist of the steam boiler, heaters, pressure relief, blowdown system with tank and controls, venturi for feedwater preheat, feedwater system with tank and pump, instrumentation, and associated controls and panels. Boiler system shall have to a feedwater system (tank and pump), with interconnecting piping, softeners, instrumentation, chemical delivery system, and associated controls and panels. Steam boiler shall be installed and operated in Paducah, KY. Construction shall meet all applicable codes, standards, and requirements to obtain a permit to operate.

D. Construction:
1. ESB-01: Rated for total of at least 6,000 lb/hr saturated steam output at 140 psig, with minimum 6 inch flanged outlet nozzle, pressure relief, air vent, water column/gauge glass, heaters, and associated appurtenances.
2. Feedwater System: Feedwater system with tank, pump, interconnecting piping, instrumentation, controls, and panels to store and deliver feedwater to the boiler. Water will be supplied from an existing process water system.
3. Blowdown System: Blowdown system with tank, controls, and interconnecting piping. System shall accept cool process water to reduce blowdown discharge to below 140°F. Tank shall be vented to atmosphere.
4. Enclosure: Install system within a weather tight enclosure.
5. SUBCONTRACTOR shall apply for and pay all fees, and obtain a permit to construct and then operate the steam plant, as required by local requirements.

E. Design/Performance Requirements:
1. ESB-01:
    a. Rated to deliver a total of at least 6,000 lb/hr saturated steam with quality greater than 99 percent at 140 psig.
    b. Capable of cold to hot standby start within 60 minutes.
    c. Furnish a venturi device to pre-heat the feedwater from 60°F to at least 160°F before entering boiler.
    d. Equip with surface and bottom blow downs with blowdown tank, piping, valves, instrumentation, and controls.
    e. Equip with adjustable pressure regulating device to maintain constant outlet steam pressure.
2. Feedwater System:
    a. Feedwater Tank:
        1) Minimum 200 gallons.
        2) Equipped with level transmitter to control feedwater pump operation, provide continuous readings, and maintain proper boiler level.
        3) Furnish and install valves, level gauge, temperature indicator, and associated controls.
    b. Feedwater Pump:
        1) Supplied from feedwater tank.
        2) Rated for at least 20 gpm at 250 ft TDH.
        3) TEFC continuous duty motor rated for outdoor environment (unless installed inside weather proof enclosure).
        4) Carbon steel body and wetted parts.

5) Prewired and prepiped to feedwater tank and steam boiler electrical control panel.
6) Control system to monitor and control system operation with required level and temperature transmitters and switches.

3. Feedwater Treatment:
   a. Provide a system to maintain proper feedwater and boiler chemistry, including softeners, injectors, drums/tanks, interconnecting piping, valves, instrumentation, and controls, as applicable.
4. Blowdown System:
   a. Blowdown Tank:
      1) Minimum 1,000 gallons
      2) Equipped with level switch (float type) to provide local alarm on high level. Set location of float to provide minimum two (2) additional days of blowdown from ESB-01 before overflow. Switch to plug into 120v receptacle powered from LC1.
      3) Include level gauge and temperature indicator.
   b. Blowdown Pump:
      1) Supplied from blowdown tank
      2) Rated for at least 20 gpm at 75 ft TDH
      3) 208V, 3 phase TEFC continuous duty motor rated for outdoor environment
      4) Manual start and stop with local hand switch
      5) Carbon steel body and wetted parts
      6) Provide hose quick connect fitting on pump discharge for draining tank

F. Utility Requirements: 480V, three phase, 60 hertz, approximately 2,000 amps

G. Instrumentation and Controls:
1. Separate control panel
   a. UL listed, built to UL 508A standards with UL label.
   b. All components prewired, including control transformer, power supply, controllers, instrumentation, motor starters, disconnects, fuses, breakers, switches, and panels to control operation of ESB-01, feedwater pump, and other systems.
2. Other Requirements:
   a. Provide alarms and shutdown signals.
   b. Include start/stop buttons with indicator lights.
   c. Provide continuous liquid level readings with low water level cutoff protection.
   d. Provide automatic liquid level volume control.
   e. Provide steam pressure gauge with isolation valve.
   f. Include temperature gauges on feedwater into and out of venturi.

H. Heat Trace System:
1. Pipes and components subject to freezing shall be metal.
2. Insulate and electric heat trace exposed piping where required to maintain water temperature above 40°F.
3. Install on feedwater and blowdown piping as shown on drawings.
4. Plug in type cables with power from receptacles (LC1).

I. Make and Model:
1. Not specified

J. Submittals:
1. Submit cut sheets, layout/configuration drawings, electrical requirements, pump performance curves, and drawings to CONTRACTOR for approval prior to procurement.
2. Installation, operations, maintenance, and instructions
    a. Must include complete installation instructions, start-up and shutdown procedures, preventative maintenance requirements, and troubleshooting guidelines.
3. Submit a list of spare parts and consumables with individual pricing.
4. Provide MSDS for all consumables.
5. Instrument calibrations and certificates (coordinate calibration range with the CONTRACTOR).

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 15 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.

C. Install piping indicated to be exposed generally at right angles or parallel to walls. Diagonal runs are prohibited unless specifically indicated otherwise or approved by CONTRACTOR.

D. Install piping out of or above walkways to allow sufficient space for access. Maintain minimum 28 inch side clearance and 7 ft overhead clearance for all walkways.

E. Install piping to permit equipment, valve, and instrument servicing.

F. Install piping at indicated slopes. If not indicated, then pipes shall generally slope to drain water back to the wells.

G. Install piping free of sags and bends.

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

I. Install steam piping to allow application of insulation.

J. Select system components in accordance with drawings and specifications. Components shall meet referenced codes and standards.

K. Verify final equipment locations.

L. Support pipes at equipment connection to not impose any loads on equipment nozzles.

M. Refer to equipment specifications for other requirements.

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 15 Sections specifying piping systems (the most stringent requirements shall apply, unless deviations approved by CONTRACTOR).

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

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

D. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B31.3 and B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

E. Welded Joints: Construct joints according to ASME B31.3 using qualified processes and welding operators.

F. Flanged Joints: Use appropriate gasket material, size, type, and thickness for service application, as specified in the drawings and specifications. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

G. Torque Requirements: Torqueing shall be in accordance with bolt and gasket manufacturer requirements. SUBCONTRACTOR to provide torque requirements, in writing, to CONTRACTOR for approval prior to bolt tightening.

3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:
   1. Install unions, in feedwater piping NPS 2 and smaller, adjacent to each valve (one side only), and at final connection to each piece of equipment.
   2. Exception: Unions shall not be used for steam and blowdown piping and equipment, unless otherwise indicated.
   3. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
   4. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
   5. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are indicated.

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

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

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

E. Install equipment in accordance with manufacturer's written instructions. Provide all necessary accessories to connect between other equipment.

3.5 PAINTING

A. Surfaces to be painted shall be clean before applying paint or surfaces treatments. Oil, grease, dirt, rust, and loose mill scale or other foreign substances shall be removed. In general, this shall be accomplished by blast cleaning. Unless otherwise specified, paints shall be applied when surfaces are thoroughly dry and only under such combination of humidity and temperature of the atmosphere and the surfaces to be painted as will cause evaporation rather than condensation. In no case shall any paint be applied during rainy, misty weather unless approval is given by the CONTRACTOR to use heating devices immediately prior to paint application. Paint manufacturer's requirements shall be followed.

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.6 CONCRETE BASES

A. The SUBCONTRACTOR shall provide suitable base for all containers, footings, and support structures to meet applicable regulations and requirements.

B. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and as specified on the drawings and specifications.

1. Construct concrete bases of dimensions indicated, but not less than 3 inches larger in both directions than supported unit.
2. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base and anchor into structural concrete floor or pedestals.
3. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

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

B. Field Welding: Comply with AWS D1.1

3.8 GROUTING

A. Refer to civil specifications.

3.9 WARRANTY

A. The SUBCONTRACTOR shall provide one (1) year warranty, at minimum, on all equipment, parts, and labor.

PART 4 – MEASUREMENT AND PAYMENT

4.1 REFER TO THE CONTRACT DOCUMENTS FOR MEASUREMENT AND PAYMENT

END OF SECTION

SECTION 15060 – HANGERS AND SUPPORTS

PART 1 – GENERAL

1.1 DOCUMENTS

A. Exhibit A, General Conditions; Exhibit B, Special Conditions, Services; Exhibit C, Quantities, Prices, and Data; Exhibit D, Scope of Work; Exhibit F, Drawings; Exhibit G, Environmental, Safety, and Health Requirements; and Exhibit I, Submittals; and Exhibit J, Labor Standards/Labor Relations, apply to this section.

1.2 SUMMARY

A. This section includes supports for mechanical system piping and equipment.

B. SUBCONTRACTOR shall provide all supporting devices as specified and as required for proper support of piping, equipment, materials and systems.

C. For supports not otherwise specified in the drawings, SUBCONTRACTOR shall provide supports for all conditions of operation, including variations in installed and operating weight of equipment and piping, to prevent excess stress and allow for proper expansion and contraction.

D. Related divisions include the following:
1. Division 15 – Mechanical
2. Division 26 – Electrical

1.3 SUBMITTALS

A. Product Data: For each type of pipe support system component

B. Supports: Pipe and equipment supports are not shown because final selections, locations, and routings are the responsibility of the SUBCONTRACTOR.

C. Welding Certificates: Copies of certificates for welding procedures and operators

D. Shop drawings for each piping system and support structure for all pipe sizes and all applicable equipment including, but not limited to, the following:
1. Manufacturer’s name
2. Model numbers
3. Materials of construction and load ratings (lb)
4. Schedule of support devices and pipe support spacing
5. Insulated pipe supports along with application chart or table
6. Insulation protection saddles and weight bearing insulation table
7. Drawings showing specific locations of any weld or bolt attachments to structure
8. Equipment mounting devices
9. Pipe guides, rollers, braces, and anchors

10. Concrete and structural steel requirements
11. All other appropriate data

1.4 DESIGN CRITERIA

A. Materials and application of pipe supports shall conform to latest requirements of ASME B31.3.

B. Supporting materials shall be hot-rolled steel and finish shall be hot-dipped galvanized or corrosion resistant unless specifically indicated.

C. Unless otherwise indicated, support devices and hardware shall be hot-rolled steel and finish shall be hot-dipped galvanized or have a corrosion resistance coating for outdoor application. Edges shall be rounded. Coat cut edges, welds, or any finish damaged with appropriate paint.

D. Material in contact with pipe shall be compatible with piping material so that neither shall have deteriorating action on the other. If materials are not compatible, provide nonmetallic separation between uninsulated steel piping and metal supports.

E. SUBCONTRACTOR is responsible for proper placement and sizing of supporting devices to accommodate insulation thickness and pitching of pipe.

1.5 QUALITY ASSURANCE

A. Welding: Qualify processes and operators according to AWS D1.1, “Structural Welding Code – Steel”

PART 2 - PRODUCTS

2.1 PIPE SHOE AND SUPPORT MANUFACTURERS

A. Manufacturers:
1. Piping Technology, Inc.
2. Pipe Supports Group
3. Anvil International
4. Cooper B-Line
5. CONTRACTOR-approved equal

2.2 STRUCTURAL SUPPORTS

A. Provide all supporting steel required for installation of mechanical equipment and materials, including angles, channels, beams, etc. to support equipment and pipe.

B. Minimum Pipe Spans:

NOMINAL PIPE SIZE	ROD DIAMETER	MAXIMUM SPAN
3/8 inch – 1-1/4 inch	3/8 inch	7 ft 0 inch
1-1/2 inch	3/8 inch	9 ft 0 inch
2 inch	3/8 inch	10 ft 0 inch
2-1/2 inch	½ inch	11ft 0 inch
3 inch	½ inch	12 ft 0 inch
3-1/2 inch	½ inch	13 ft 0 inch
4 inch	5/8 inch	14 ft 0 inch
5 inch	5/8 inch	16 ft 0 inch
6 inch	¾ inch	17 ft 0 inch
8 inch	¾ inch	19 ft 0 inch
10 inch	7/8 inch	22 ft 0 inch
12 inch	7/8 inch	23 ft 0 inch
14 inch	1 inch	25 ft 0 inch
16 inch	1 inch	27 ft 0 inch

2.3 PRE-INSULATED PIPE SHOES

A. For steam systems, nonstructural insulation shall consist of water-resistant calcium silicate with minimum density of 13 pcf and minimum compressive strength of 160 psi. Structural inserts shall be used as recommended by manufacturer to meet load ratings. Fiberglas insulation is also acceptable. All insulation shall be of sufficient thickness to ensure surface temperatures are below 140°F.

B. Structural inserts shall be water-resistant, high-density calcium silicate with minimum density of 28 pcf and minimum compressive strength of 900 psi. Structural inserts shall be used as recommended by manufacturer to meet load ratings.

C. Use vapor barrier Kraft paper (indoors) or aluminum jacket (outdoors) around insulation. Insulation jackets shall be aluminum conforming to ASTM A-527. A minimum 6-inch wide jacket strip shall be installed and sealed over the seam between the pipe insulation jacket and the pre-insulated pipe support jacket.

D. Pre-insulated pipe supports shall be load rated. Load ratings shall be established by pipe support manufacturer based upon testing and analysis in conformance with the latest edition of ASME B31.3.

E. Pipe support spacing shall be as allowed by the design specifications with a tolerance of ± one pipe diameter.

2.4 BOLTS, NUTS, STUDS AND WASHERS

A. Hot dip galvanized finish

2.5 U-BOLTS

A. Hot dip galvanized finish

2.6 METAL FRAMING SUPPORT SYSTEM (STRUT SYSTEM)

A. Manufacturers: Unistrut, B-Line Strut Systems, Power-Strut, Superstrut, and Kindorf

B. Channels to have hot dip galvanized finish

C. Channels shall not be lighter than 12 gauge

D. Channels shall be slotted

2.7 PIPE GUIDES

A. Guides shall be as specified by the manufacturer.

2.8 PIPE ANCHORS

A. Anchors shall be no-moment type, as specified by the manufacturer.

2.9 PIPE HANGERS

A. Uninsulated pipes 2 inch and smaller:
1. Adjustable steel swivel ring band type
2. Adjustable steel swivel J-hanger type
3. Malleable iron ring hanger
4. Adjustable steel clevis hanger

B. Uninsulated pipes 2-1/2 inch and larger:
1. Adjustable steel clevis hanger
2. Pipe roll with sockets
3. Adjustable steel yoke pipe roll

C. Insulated pipe – Steam and Blowdown Water:
   1. 2 inch and smaller pipes, use adjustable steel clevis with galvanized sheet metal shield
   2. 2-1/2 inch and larger pipes:
      a. Adjustable steel yoke pipe roll with pipe covering protection saddle
      b. Pipe roll with sockets with pipe covering protection saddle

D. Insulated pipe – Feedwater piping:
   1. 2 inch and smaller pipes: use Unistrut

2.10 PIPE CLAMPS

A. When flexibility in the hanger assembly is required due to horizontal movement, use pipe clamps with weldless eye nuts. For insulated pipes, use double bolted pipe clamps.

2.11 MULTIPLE OR TRAPEZE HANGERS

A. Trapeze hangers shall be constructed from 12-gauge, roll-formed ASTM A 1011 SS Gr. 33 structural steel channel, 1-5/8 inches by 1-5/8 inches, as required.

B. Mount pipes to trapeze with two piece pipe straps sized for outside diameter of pipe.

C. For pipes subjected to axial movement:
   1. Strut mounted roller support with pipe protection shield or saddle on insulated lines
   2. Strut mounted pipe guide

2.12 WALL SUPPORTS

A. Pipes 4 inch and smaller: Carbon steel hook or J-hanger.

B. Pipes larger than 4 inch: welded steel bracket and pipe straps, or welded steel bracket with roller chair or adjustable steel yoke pipe roll. Use pipe protection shield or saddles on insulated lines.

2.13 FLOOR SUPPORTS

A. Hot piping under 6 inch and all cold piping:
   1. Carbon steel adjustable pipe saddle and nipple attached to steel base stand sized for pipe elevation. Pipe saddle shall be screwed or welded to appropriate base stand.

B. Hot piping 6 inch and larger:
   1. Adjustable roller stand with base plate
   2. Adjustable roller support with steel support sized for elevation

2.14 VERTICAL SUPPORTS

A. Steel riser clamp sized to fit outside diameter of pipe accounting for any insulation.

2.15 ACCESSORIES

A. Hanger rods shall be threaded either ends, or continuous threaded rods of circular cross section. Use adjusting locknuts at upper attachments and hangers. No wire, chain, or perforated straps are allowed.

B. Shields shall be 180 degree galvanized sheet metal, 12 inch minimum length, 18 gauge minimum thickness, designed to match outside diameter of the insulated pipe.

C. Pipe protection saddles shall be formed from carbon steel, 1/8 inch minimum thickness, sized for insulation thickness. Saddles for pipe sizes greater than 12 inch shall have a center support rib.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install pipe supports and guides to allow for free expansion of piping in accordance with the drawings or manufacturer requirements. Supports shall account for weights of pipe, insulation, and pressure test media.

B. Piping shall not be supported by other piping, unless specified otherwise.

C. Pipe supports are not allowed to penetrate vapor barrier of pipe insulation.

D. Install adequate supports during erection of piping so as not to overstress either piping or equipment to which piping is connected.

E. Support vertical non-insulated piping at bottom of riser secured and anchored to concrete floor structure, unless specified otherwise.

F. Install supports to provide indicated pipe slopes and so maximum pipe deflections are not exceeded.

G. Install insulated pipe support shoes at support points of all insulated pipe.

H. Install anchors where shown on the drawings.

I. Clean field welds and abraded areas.

J. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

K. Pipes shall be adequately supported by pipe hangers and supports. Hangers for insulated pipes shall be sized to accommodate the insulation thickness.

L. Install hangers within 12 inches of each horizontal elbow. Install hangers to provide a minimum of 1/2 inch space between finished covering and adjacent work.

M. Support vertical piping independently of connected horizontal piping.

N. Where several pipes can be installed in parallel and at the same elevation, provide trapeze hangers.

O. Do not support piping from other pipes, ductwork, or other equipment.

END OF SECTION

SECTION 15080 - PIPE INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Exhibit A, General Conditions; Exhibit B, Special Conditions, Services; Exhibit C, Quantities, Prices, and Data; Exhibit D, Scope of Work; Exhibit F, Drawings; Exhibit G, Environmental, Safety and Health Requirements; and Exhibit I, Submittals; and Exhibit J, Labor Standards/Labor Relations, apply to this section.

1.2 SUMMARY

A. This section includes preformed, rigid, and flexible pipe insulation, insulating cements, field-applied jackets, accessories and attachments, and sealing compounds.

B. Related sections include the following:
1. Division 15, Section “Valves,” for insulation for valves
2. Division 15, Section “Process Piping,” for pipe insulation

1.3 SUBMITTALS

A. Product Data: Identify thermal conductivity, thickness, weights, and jackets (both factory and field applied, if any), for each type of product to be supplied and for each process system.

B. Shop Drawings: Show fabrication and installation details for the following (specify applicable process system):
1. Application of protective shields, saddles, and inserts at pipe supports for each type of insulation and support
2. Attachment and covering of heat trace inside insulation
3. Insulation application at pipe expansion joints for each type of insulation
4. Insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation
5. Removable insulation at piping specialties and equipment connections
6. Application of field-applied jackets.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Insulation materials and accessories shall be installed in a workmanlike manner by skilled and experienced workers who are regularly engaged in commercial insulation work.

B. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Outdoors on steam pipe: Flame-spread rating of 75 or less and smoke-developed rating of 150 or less.
2. Insulation Installed Outdoors on water pipe: Flame-spread rating of 25 or less and smoke-developed rating of 50 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type, grade, and maximum use temperature.

B. Storing: All insulation materials and accessories delivered to the jobsite shall be stored in a safe, dry place.

C. The SUBCONTRACTOR shall use whatever means necessary to protect the insulation materials and accessories before, during, and after installation. No insulation materials and accessories shall be installed that have been damaged in any way.

D. Wet insulation shall not be installed unless the SUBCONTRACTOR can demonstrate that when fully dried out (either before installation or as a result of system operation) it will have an equivalent performance to new fully dry insulation. Approval must be obtained from the CONTRACTOR prior to installing wet or previously wet insulation.

1.6 COORDINATION

A. Coordinate with installation of pipe supports.

B. Coordinate clearance requirements with piping installer for insulation application.

C. Coordinate with installation and testing of electric heat tracing.

D. Coordinate with testing pipe and inspecting welds.

1.7 SCHEDULING

A. Schedule insulation application after testing piping systems and, where required, after installing and testing heat-trace tape, testing pipes, and inspecting welds. Insulation application may begin on segments of piping that are not at inspection points or have satisfactory test results.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or CONTRACTOR-approved equal:

1. Fiberglass Insulation:
   a. Johns Manville
   b. Owens-Corning
   c. Pittsburgh-Corning
2. Elastomeric Foam Insulation:
   d. Rubatex Corporation
   e. Armacell
   f. Totaline

2.2 INSULATION REQUIREMENTS

A. Steam Piping, Valves, and Fittings:
   1. Aboveground – Fiberglass, calcium silicate, Foamglas, or thermal blankets, jacketed with Kraft paper (indoors) or aluminum (outdoors), or CONTRACTOR-approved equal

B. Water (Cold) Piping, Valves, and Fittings: Elastomeric or Foamglas, or CONTRACTOR- approved equal, no jacketing required unless needed to protect insulation from wet weather

C. Water (Hot) Piping, Valves, and Fittings: Fiberglass, calcium silicate, Foamglas, or thermal blankets, jacketed with Kraft paper (indoors) or aluminum (outdoors), or CONTRACTOR-approved equal

2.3 INSULATION MATERIALS

A. Mineral-Fiber Insulation: Glass fibers bonded with a thermosetting resin complying with the following with the following properties:
   1. Molded fibrous glass pipe insulation: ASTM C547
   2. Blanket insulation: ASTM C553, Type II, without facing
   3. Vapor-Retarder: ASTM C1136
   4. Mineral-Fiber Insulating Cements: ASTM C195

B. Elastomeric Insulation: White flexible cellular elastomeric ASTM C534 complying with the following properties:
   1. "K" value – ASTM C177 or C518
   2. Minimum service temperature: Minus 40˚F
   3. Maximum service temperature: Plus 220˚F
   4. Maximum moisture absorption: ASTM D1056
   5. Moisture vapor transmission: ASTM E96

C. Foamglas Insulation:
   1. Manufactured in accordance with ASTM C552, "Standard Specification for Cellular Glass Thermal Insulation" or EN14305, "Thermal insulation products for building equipment and industrial installations – factory made cellular glass (CG) products – Specification"
   2. Meet the requirements of ISO 9001:2008. FOAMGLAS® pipe insulation shall be fabricated according to the requirements of ASTM C1639, "Standard Specification for Fabrication of Cellular Glass Pipe and Tubing Insulation," DIN EN 13 167 or AGI Q 137, "Tubing Insulation"

D. Prefabricated Thermal Insulating Fitting Covers: Comply with ASTM C450 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges as applicable.

E. Water and cold system fittings, flanges and valve bonnets can be insulated with pre-formed fittings, fabricated sections of insulation, or insulating cement. Thickness shall be equal to adjacent pipe insulation. For the steam piping, finish shall be with pre-formed Kraft paper (indoors) or aluminum (outdoors) fitting covers with all joints weather sealed. All valve handwheels shall remain accessible.

F. Steam and hot vapor fittings, flanges, and valve bonnets and water unions, flanges, check valves, and flow meters can be insulated with flexible thermal insulation blankets equal to Owens Corning Type I TIW Fiberglass Blanket, encased in a Bisco HT-101 Silicone Coated Fiberglass cloth, and secured according to manufacturer's written instructions. Blanket thickness shall be 1 inch for pipe and valve sizes up to 3 inches in diameter, and 2 inches for pipes and valves greater than or equal to 3 inches in diameter. All valve handwheels shall remain accessible.

G. Pre-insulated pipe supports can be provided for the steam pipes at each of the supports. The SUBCONTRACTOR shall install piping insulation up to the supports and use low-density blanket insulation to fill gaps and match thickness. A 6-inch wide by 12-inch long jacket strip shall be installed to seal the seam between the pre-insulated pipe support and the pipe insulation, allowing for thermal expansion.

2.4 FIELD-APPLIED JACKETS

A. General: ASTM C1136, Type II, unless otherwise indicated

B. Aluminum Jacket: Factory cut and rolled with 0.016 inch thickness and smooth finish; comply with ASTM B209, 3003 alloy, H-14 temper

1. Moisture Barrier: 1-millimeter thick, heat-bonded polyethylene and Kraft paper.
2. Elbows: Preformed, 45- and 90-degree, short- and long-radius elbows; same material, finish, and thickness as jacket.
3. Jacket shall be secured in accordance with the jacket manufacturer’s recommendations with joints applied so they will shed water and shall be sealed completely.

2.5 ACCESSORIES AND ATTACHMENTS

A. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for cloth and Type II for tape. Woven glass-fiber fabrics, plain weave, presized at a minimum of 8 oz/sq yd; Tape Width: 4 inches

B. Bands: ¾-inch wide in one of the following materials compatible with jacket: Aluminum: 0.007-inch thick

C. Wire: 0.062-inch, soft-annealed, stainless steel

2.6 VAPOR RETARDERS

A. Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

2.7 PROTECTIVE COATING

A. UV Resistant Coating: Material recommended by the manufacturer to protect elastomeric foam from UV rays

B. Kraft paper for hot piping (indoors) or CONTRACTOR-approved equal

C. Aluminum jacket for hot piping (outdoors) or CONTRACTOR-approved equal

D. PITTWRAP jacketing for Foamglas or CONTRACTOR-approved equal

E. As recommended by manufacturer or CONTRACTOR-approved equal

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry pipe and fitting surfaces. Remove materials that will adversely affect insulation application. Comply with manufacturer’s written instructions.

B. Ensure that required supports and pressure testing of piping and fittings has been completed prior to installing insulation.

3.3 GENERAL APPLICATION REQUIREMENTS

A. Follow all manufacturer preparation and installation requirements, including use of recommended adhesives, bands, tapes, and other materials.

B. Apply insulation materials, accessories, and finishes according to the manufacturer’s written instructions and recognized industry practices; with smooth, straight, and even surfaces; and free of voids throughout the length of piping, including fittings, valves, and specialties.

C. Install insulation on piping subsequent to installation of heat tracing and satisfactory completion of acceptance tests. Insulation can be installed prior to performing tests for those sections not subject to inspection.

D. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

E. Apply insulation with longitudinal seams at top and bottom of horizontal pipe runs, unless specified otherwise.

F. Apply multiple layers of insulation with longitudinal and end seams staggered.

G. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

H. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.

I. Keep insulation materials dry during application and finishing.

J. Apply insulation with tight longitudinal seams and end joints. Butt insulation joints firmly to ensure complete, tight fit over all piping surfaces. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

K. Apply insulation with the least number of joints practical.

L. Maintain the integrity of factory-applied vapor barrier jacketing on all pipe insulation, protecting it against puncture, tears, or other damage. All staples used on cold pipe insulation shall be coated with suitable sealant to maintain vapor barrier integrity.

M. Refer to special instructions for applying insulation over fittings, valves, and specialties.

N. Apply adhesives and mastics at the manufacturer's recommended coverage rate.

O. Steam trap and vent assemblies, including piping and valves insulated using manufacturer supplied or recommended insulation.

P. Steam hoses shall be insulated with thermal blankets.

Q. Install removable insulation blankets over unions, flanges, check valves, strainers, separators, and instruments.

3.4 MINERAL-FIBER INSULATION APPLICATION (STEAM)

A. Apply insulation to straight pipes and tubes per manufacturer’s written instructions and generally as follows:

1. Secure each layer of preformed pipe insulation to pipe with wire, tape, or bands without deforming insulation materials.
2. Butt insulation against preinsulated pipe supports and seal seams with vapor retarder mastic.

3. Where vapor retarders are required, seal longitudinal seams and end joints with vapor-retarder mastic. Apply vapor retarder to ends of insulation at intervals of 15 to 20 feet to form a vapor retarder between pipe insulation segments.
4. Apply jacket over mineral-fiber insulation.

B. Apply insulation to flanges as follows:
1. Apply thermal insulation blankets according to manufacturer's written instructions.

C. Apply insulation to fittings per manufacturer’s written instructions and generally as follows:
1. Apply premolded insulation sections of the same material as straight segments of pipe insulation, when available. Secure according to manufacturer's written instructions.
2. When premolded insulation is not available, apply mitered sections of pipe insulation, or glass-fiber blanket insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire, tape, or bands.
3. Cover fittings with standard fitting covers. Overlap covers on pipe insulation jackets at least 2 inches at each end. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

D. Apply insulation to valves and specialties as follows:
1. Apply thermal insulation blankets according to manufacturer's written instructions.

3.5 ELASTOMERIC FOAM INSULATION APPLICATION (WATER)

A. Apply insulation to straight pipes and tubes as follows (Note: all aboveground exposed water pipe will have electric heat trace wire):
1. Use insulation with ID for next larger size pipe (half size or full size). Do not route out the insulation or allow the heat trace wire to embed into the insulation.
2. Install 1-inch wide by 9-inches long spacers at 18-inch centers between pipe OD and insulation ID. Spacer thickness shall be sufficient to provide support for the pipe insulation. Spacers shall be fabricated from the same material as the pipe insulation of equal or higher density grade. Center every other spacer at the pipe insulation butt joint. Note: Spacers are not required if half size larger ID insulation is used, and a tight fit can be maintained.
3. Secure each layer of insulation around pipe with preapplied adhesives or manufacturer specified neoprene adhesives.
4. At butt joints, apply proper adhesives to ensure continuous fit.
5. Install draft stops of the same material as the insulation on vertical pipes with approximately 4 ft of spacing. The draft stop should completely fill the void between the pipe and the insulation. Secure the draft stop in place with manufacturer recommended tape. Draft stops shall be located at the top and bottom of vertical sections, and at the terminations above and below flanged and screwed connections.
6. If cracks or imperfections cannot be adequately closed, replace the affected sections.
7. Do not bevel terminated insulation at flanges, valves, or specialties.

B. Apply insulation to fittings and elbows as follows:
1. Apply premolded insulation sections of the same material as straight segments of pipe insulation, when available. Secure according to manufacturer’s written instructions.
2. When premolded sections of insulation are not available, apply mitered sections of insulation. Secure insulation materials with wire, tape, or bands.

C. Apply insulation to valves and specialties as follows:
1. Apply fitting covers insulated with material equal in thickness and composition to adjoining insulation. Secure according to manufacturer's written instructions.

D. Apply thermal insulation blankets to unions, flanges, check valves, and flow meters according to manufacturer’s written instructions.

E. Apply protective coating as follows:
1. Apply two coats with brush, roll, or spray.
2. Ensure elastomeric foam surface is clean and free of oil, dirt, and grease. If necessary, clean with denatured alcohol.
3. Follow manufacturer requirements for spreading rate and drying times.
4. Adhere to manufacturer requirements for low ambient temperature installations.

3.6 FIELD-APPLIED JACKET APPLICATION

A. Apply metal jacket for steam piping where indicated, with 2 inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with aluminum bands 12 inches on-center and at end joints.

3.7 PIPING SYSTEM APPLICATIONS

A. Insulation materials and thicknesses are generally not specified on drawings. In general, piping 2 inches and greater shall have 2-inch thick insulation; and piping less than 2 inches shall have 1-inch thick insulation, unless otherwise specified.

B. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:
1. Vibration-control devices
2. Drainage piping
3. Relief valve exhaust lines
4. Gauges and instruments
5. Components prohibited by the manufacturer

3.8 FIELD QUALITY CONTROL

A. Inspection: CONTRACTOR may perform the following field quality-control inspections, after installing insulation materials, jackets, and finishes, to determine compliance with requirements:
1. Inspect fittings and valves randomly selected.
2. Remove fitting covers from 2 elbows or 1 percent of elbows, whichever is less, for various pipe sizes.
3. Remove fitting covers from 2 valves or 1 percent of valves, whichever is less, for various pipe sizes.

B. Insulation applications will be considered defective if sample inspection reveals noncompliance with requirements. Remove defective work and replace with new materials according to these Specifications.

C. Reinstall insulation and covers on fittings and valves uncovered for inspection according to these specifications.

END OF SECTION

SECTION 15110 – VALVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Exhibit A, General Conditions; Exhibit B, Special Conditions, Services; Exhibit C, Quantities, Prices, and Data; Exhibit D, Scope of Work; Exhibit F, Drawings; Exhibit G, Environmental, Safety, and Health Requirements; and Exhibit I, Submittals; and Exhibit J, Labor Standards/Labor Relations, apply to this section.

1.2 SUMMARY

A. This section includes the following general-duty valves:
1. Ball valves
2. Butterfly valves
3. Check valves.
4. Gate valves
5. Globe valves

1.3 DEFINITIONS

A. The following are standard abbreviations for valves:
1. CWP: Cold working pressure
2. EPDM: Ethylene-propylene-diene terpolymer rubber
3. FKM: Fluoroelastomer (also referred to as Viton)
4. NBR: Acrylonitrile-butadiene rubber
5. PTFE: Polytetrafluoroethylene plastic
6. SWP: Steam working pressure
7. TFE: Tetrafluoroethylene plastic
8. WOG: Water, oil, gas

1.4 SUBMITTALS

A. Product Data: For each type of valve indicated, include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; applicable codes and standards; and accessories.

1.5 CODES AND STANDARDS

A. ASME Compliance: ASME B31.3

B. Steel Valves: ASME B16.34

C. Bronze Valves: ASME B16.24

D. Cast Iron Valves: ASME B16.1

E. NSF Compliance: NSF 61 for potable-water service

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set angle, gate, and globe valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. Set butterfly valves closed or slightly open.
6. Block swing check valves in either closed or open position.
7. Cover all air line openings.

B. Use the following precautions during storage:
1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures or wrapping.

C. Use sling to handle large valves; and rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the work include, but are not limited to, the manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 VALVES, GENERAL

A. Refer to Part 3 for applications of valves.

B. Steel Valves: All sizes for steam system (including blowdown), unless otherwise specified or CONTRACTOR-approved.

C. Bronze Valves: NPS 2 and smaller with threaded ends for water systems only, unless otherwise indicated or CONTRACTOR-approved.

D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system design pressures and temperatures.

E. Valve Sizes: Same as upstream pipe, unless otherwise indicated. Size globe valve for flow rate conditions based on flow coefficient.

F. Valve Actuators:
   1. Gear Drive: For quarter-turn valves NPS 10 and larger
   2. Handwheel: For valves other than quarter-turn types
   3. Lever Handle: For quarter-turn valves NPS 4 and smaller, except plug and needle valves, and for butterfly valves

G. Valve Flanges:
   1. Cast Iron: ASME B16.1
   2. Steel: ASME B16.5
   3. Bronze: ASME B16.24

H. Valve Bypass and Drain Connections: MSS SP-45

I. Valve Threads: ANSI B1.20.1

J. Valve Tags: Furnish each valve with 1-1/2 inch brass tag with stamped and red-filled numbers. Valve identifications shall be 1/2 inch letters and numbers. Secure tag to valve using brass chain and "S" hook. Secure chain to valve with copper or monel meter seals.

2.3 BRONZE AND FERROUS-ALLOY BALL VALVES

A. Manufacturers:
   1. American Valve, Inc.
   2. Conbraco Industries, Inc.
   3. Flowserve; Noble Alloy
   4. Milwaukee Valve Company
   5. NIBCO INC.
   6. CONTRACTOR-approved equal

B. Bronze and Ferrous-Alloy Ball Valves, General: MSS- SP-72

C. Bronze and Ferrous-Alloy Ball Valves: Class 150, full port stainless steel ball, PTFE seats, blowout-proof stem

2.4 FERROUS-ALLOY BUTTERFLY VALVES

A. Manufacturers:
   1. Crane Co.; Centerline
   2. Flowserve; Durco
   3. Grinnell Corporation
   4. Mueller Steam Specialty
   5. NIBCO INC.
   6. CONTRACTOR-approved equal

B. Ferrous-Alloy Butterfly Valves, General: API 609

C. Ferrous-Alloy Butterfly Valves: Class 150, tight shutoff, stainless steel disc, shaft, and bearings, Viton lining, except EDPM for cooling tower water, wafer, or lug type with one- or two-piece stem, unless indicated otherwise.

2.5 BRONZE CHECK VALVES

A. Manufacturers:
   1. Horizontal Lift Check Valves with Metal Disc:
      a. Crane Co.
      b. Red-White Valve Corp.
   2. Swing Check Valves with Metal Disc:
      a. American Valve, Inc.
      b. Crane Co.; Crane Valve Group; Crane Valves
      c. NIBCO INC.
      d. Red-White Valve Corp.
      e. Watts Industries, Inc.; Water Products Div.
   3. CONTRACTOR-approved equal

B. Bronze Check Valves, General: MSS SP-80

C. Bronze Check Valves: Class 150, bronze body with bronze disc and renewable seat

2.6 BRONZE GATE VALVES

A. Manufacturers:
   1. Crane Co.
   2. Grinnell Corporation
   3. Milwaukee Valve Company
   4. NIBCO INC.
   5. Powell, Wm. Co.
   6. CONTRACTOR-approved equal

B. Bronze Gate Valves, General: MSS SP-80

C. Bronze Gate Valves: Class 150, bronze body with nonrising stem, bronze solid wedge, and union-ring bonnet

2.7 BRONZE GLOBE VALVES

A. Manufacturers:
   1. Cincinnati Valve Co.
   2. Crane Co.
   3. Grinnell Corporation
   4. Milwaukee Valve Company
   5. NIBCO INC.
   6. CONTRACTOR-approved equal.

B. Bronze Globe Valves, General: MSS SP-80.

C. Bronze Globe Valves: Class 150, bronze body with bronze disc and union-ring bonnet.

2.8 STEEL GATE VALVES

A. Manufacturers:
   1. Vogt
   2. Velan
   3. Aloyco
   4. Milwaukee
   5. Crane
   6. CONTRACTOR-approved equal

B. Steel Gate Valves, General: ASME B16.34

C. Steel Gate Valves: Class 150 or 300 as applicable with outside screw and yoke and solid wedge or flexible wedge disc, and trim suitable for steam service

2.9 STEEL BALL VALVES

A. Manufacturers:
   1. Vogt
   2. Velan
   3. MCF Valves
   4. Aloyco
   5. CONTRACTOR-approved equal

B. Steel Ball Valves, General: B16.34

C. Steel Ball Valves: Class 150 with 316 stainless steel ball, reinforced reinforced PTFE seats and seals, lever handle, and trim suitable for steam service

2.10 STEEL GLOBE VALVES

A. Manufacturers:
   1. Vogt
   2. Velan

3. Milwaukee
4. CONTRACTOR-approved equal

B. Steel Globe Valves, General: ASME B16.34

C. Steel Globe Valves: Class 150 with outside screw and yoke and trim suitable for steam service

2.11 PRESSURE RELIEF VALVES

A. Size and Capacity:
1. As required for equipment and system protection, accounting for 110 percent of expected flow rate at the lift setpoint.
2. As recommended by manufacturer and/or specified on the drawings.

B. Construction: Class 150 minimum inlet and outlet, carbon steel or cast-iron with stainless steel trim, flanged ends, and orifice sized for full capacity, factory set and sealed.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine piping system for compliance with drawings and specifications.

B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

C. Operate valves in positions from fully opened to fully closed. Examine guides and seats made accessible by such operations.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

F. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE APPLICATIONS

A. Refer to piping Sections for specific valve applications. If valve applications are not indicated, or approved by the CONTRACTOR, use the following:
1. Shutoff Service: Ball, butterfly**,** or gate valves
2. Steam Boiler Shutoff Service: Gate or gate/check valves
3. Throttling Service: Globe valves
4. Pump Discharge: Swing check valves

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP class or CWP ratings may be substituted.

C. Water Piping: Use the following types of valves:

1. Ball Valves, NPS 2 and Smaller: Two-piece, 600-psig CWP rating, bronze
2. Ball Valves, NPS 2-1/2 and Larger: Class 150, ferrous alloy
3. Butterfly Valves, NPS 2-1/2 and Larger: Flanged, 150-psig CWP rating, ferrous alloy, with EDPM liner
4. Swing Check Valves, NPS 2 and Smaller: Class 150, bronze
5. Swing Check Valves, NPS 2-1/2 and Larger: Class 250, cast-iron
6. Gate Valves, NPS 2 and Smaller: Class 150, bronze
7. Globe Valves, NPS 2 and Smaller: Class 150, bronze
8. Globe Valves, NPS 2-1/2 and Larger: Class 250, bronze-mounted cast iron

D. Steam Piping: Use the following types of valves:

1. Swing Check Valves, NPS 2 and Smaller: Class 150, steel or bronze
2. Swing Check Valves, NPS 2-1/2 and Larger: Class 150/300, steel
3. Gate Valves, NPS 2 and Smaller: Class 150, steel or bronze; Class 300, steel
4. Gate Valves, NPS 2-1/2 and Larger: Class 150/300, OS&Y, steel
5. Globe Valves, NPS 2 and Smaller: Class 150, steel or bronze
6. Globe Valves, NPS 2-1/2 and Larger: Class 150/300, steel
7. Valves NPS 2 and Smaller: Threaded ends, flanged ends, socket-weld, or butt-weld
8. Valves NPS 2-1/2 and Larger: Flanged ends, socket-weld or butt-weld

E. Vapor Piping: Use the following types of valves:

1. Ball Valves, NPS 2 and Smaller: Two-piece, 600-psig CWP rating, bronze
2. Ball Valves, NPS 2-1/2 and Larger: Class 150, ferrous-alloy
3. High-Pressure Butterfly Valves, NPS 3 and Larger: Flange, Class 150, ferrous-alloy
4. Swing Check Valves, NPS 2 and Smaller: Class 150, bronze
5. Swing Check Valves, NPS 2-1/2 and Larger: Class 125, gray iron
6. Gate Valves, NPS 2 and Smaller: Class 125, bronze
7. Gate Valves, NPS 2-1/2 and Larger: Class 125 OS&Y, bronze-mounted cast iron
8. Globe Valves, NPS 2 and Smaller: Class 125, bronze
9. Globe Valves, NPS 2-1/2 and Larger: Class 125, bronze-mounted cast iron
10. Plug/Needle Valves, NPS 1 and Smaller: Class 125, bronze

F. Select valves, except wafer and flangeless types, with the following end connections (except steam valves shall be flanged, butt-weld, or socket-weld, unless indicated otherwise):

1. For Steel Piping, NPS 2 and Smaller: Threaded ends
2. For Steel Piping, NPS 2-1/2 to NPS 3: Flanged or threaded ends
3. For Steel Piping, NPS 4 and Larger: Flanged ends

3.3 VALVE INSTALLATION

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

C. Locate valves for easy access and provide separate support where necessary.

D. Install valves in horizontal piping with stem at or above center of pipe.

E. Install valves in position to allow full stem movement with no interferences while operating the handwheel or lever from full open to full close.

F. Install check valves for proper direction of flow and as follows:
1. Swing Check Valves: In horizontal position with hinge pin level

3.4 JOINT CONSTRUCTION

A. Refer to Division 15 Section, "Basic Mechanical Materials and Methods," for basic piping joint construction.

3.5 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if persistent leaking occurs.

END OF SECTION

SECTION 15210 – PROCESS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Exhibit A, General Conditions; Exhibit B, Special Conditions, Services; Exhibit C, Quantities, Prices, and Data; Exhibit D, Scope of Work; Exhibit F, Drawings; Exhibit G, Environmental, Safety, and Health Requirements; and Exhibit I, Submittals; and Exhibit J, Labor Standards/Labor Relations, apply to this section.

B. Related sections include the following:
1. Division 15, section "General Requirements for Mechanical Work," for general piping materials and installation requirements.
2. Division 15, section "Basic Mechanical Materials and Methods," for general piping materials and installation requirements.
3. Division 15, section "Hangers and Supports," for pipe supports, product descriptions, and installation requirements.
4. Division 15, section "Valves," for general-duty gate, globe, ball, butterfly, and check valves.

1.2 SUMMARY

A. This section includes piping and components for the process systems: steam, feedwater, and blowdown water.

1.3 SYSTEM DESCRIPTION

A. Steam piping:
1. System ID - STM
2. Used to convey saturated steam from the Steam Boiler ESB-01 to the steam injection wells SIW-01S and SIW-01D)
3. Design conditions – 6,000 lb/hr, 150 psig
4. Maximum pipe velocity – 100 ft/sec
5. Maximum pressure loss – 1 psi/100 ft
6. Code designation – Category D, Class 150
7. Governing code is ASME B31.3

B. Feedwater piping:
1. System ID – FWS
2. Used to convey facility process water to the steam boiler ESB-01
3. Design conditions – 20 gpm, 150 psig, 100°F
4. Maximum pipe velocity – 8 ft/sec
5. Maximum pressure loss – 1 psi/100 ft
6. Code designation – Category D Class 150
7. Governing code is ASME B31.3

C. Blowdown water piping:
1. System ID – BDW
2. Used to convey waste water from the steam boiler waste storage tank
3. Design conditions – 60 gpm, 150 psig
4. Maximum pipe velocity – 8 ft/sec
5. Maximum pressure loss – 1 psi/100 ft
6. Code designation – Category D Class 150
7. Governing code is ASME B31.3

1.4 SUBMITTALS

A. Product Data: For each type of pipe protection device, special-duty valve, trap, pipe, hose, equipment, tube, fitting, and associated components, including rated capacities and accessories.

B. Shop Drawings: For items that will require field measurements for fabrication, provide shop drawings with dimensions, dry and flooded weights, loadings, and required clearances, method of field assembly, components, calculations, anchoring, and location and size of each field connection.

C. Welding Documentation and Certificates:
1. Welder procedure qualification reports
2. Weld procedure specifications prior to welding
3. Weld radiographic inspection reports
4. Filler metal control procedure
5. List of names and identification symbols for qualified welders prior to welding
6. Weld maps
7. Any other documentation required by applicable ASME or AWS codes

D. Field Test Reports: Written reports of tests specified in Part 3 of this section. Include the following:
1. Test procedures used,
2. Drawing(s) with test boundaries,
3. Test results that comply with requirements, and
4. Failed test results and corrective action taken to achieve requirements.

E. Pressure Test Procedure (at least one week prior to performing test) for CONTRACTOR review and approval.

F. Calibration Certificates for instruments used, process systems, and for pressure testing.

G. Maintenance Data: For traps, vacuum breakers, valves, strainers, and ancillary components to include in maintenance manuals.

H. Pressure vessel Section VIII documentation and calculations if pressure vessels are provided.

1.2 QUALITY ASSURANCE

A. Welding:
   1. Qualify processes and operators according to the ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications." Provide weld record map with isometrics showing all welds and welder identifications. Isometrics shall be in AutoCAD, version 2012 minimum.
   2. Welding shall be performed by individuals who are currently qualified in accordance with ASME B31, Code for Pressure Piping, and Section IX.

B. ASME Compliance: Comply with ASME B31.3 for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label, unless otherwise specified.

1.3 COORDINATION

A. Coordinate layout and installation of process piping with the CONTRACTOR.

B. Coordinate pipe fitting pressure classes with products specified in related sections.

C. Coordinate pipe testing and weld inspections with insulation installation with the CONTRACTOR.

D. Coordinate facility operations and schedule with the CONTRACTOR.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. All materials shall meet or exceed all applicable referenced standards, federal, state, and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

B. Steel Threaded Fittings – All threaded fittings shall wrought carbon or alloy steel threaded fittings conforming to ASTM A234, or malleable iron threaded fittings conforming to ASME/ANSI B16.3.

C. Welded Fittings – All weld fittings shall be forged or wrought carbon steel, socket, or butt welded fittings conforming to ASME B16.11 or ASME B16.9.

D. Steel Flanges:
   1. All steam flanges NPS 2-1/2 and larger shall be carbon steel, weld neck, raised face, conforming to ANSI B16.5 or API-605.
   2. All other flanges can be weld neck or slip-on, raised face.
   3. Bolts shall be carbon steel with semi-finished hexagon nuts of American Standard heavy dimensions. All-thread rods are not an acceptable substitute for flange bolts. Bolts shall have a tensile strength of 60,000 psi and an elastic limit of 30,000 psi.

E. Gaskets:

1. All flanges shall have gaskets. Place gasket between flanges of flanged joints. Gaskets shall fit within the bolt circle on raised face flanges, and shall be full face on flat face flanges.
2. All gaskets used on steam system shall be Flexitallic Style CG, AP1061 spiral wound 30455 with Grafoil fill at least 1/8-inch thick, as manufactured by Garlock or CONTRACTOR-approved equal, regardless of pipe size and pressure.
3.
4. All gaskets used on water systems shall be compatible for service conditions, at least 1/8-inch thick.
5. The inside diameter of such gaskets shall conform to the nominal pipe size and the outside diameter shall be such that the gasket extends outward to the studs or bolts employed in the flanged joint.

2.2 PIPE AND FITTINGS

A. The basis of the design is threaded NPS 2 and smaller and welded and flanged for NPS 2-1/2 and larger. The SUBCONTRACTOR may elect to weld smaller sizes. CONTRACTOR approval is required for threading larger sizes.

B. Steam:

6. Pipe – NPS 2 and Smaller: Carbon steel, ASTM A53 or A106, Grade B, seamless, Schedule 80
   a. Fittings: Forged steel, ASME B16.11, Class 150
   b. Joints: Socket-weld or threaded
   c. Unions: Forged steel, ASTM A105, socket weld, 3000 lb, and stainless steel seats
   d. Gaskets: Flexitallic Style CG, API 601 spiral wound 304SS with Grafoil Fill, or CONTRACTOR-approved equal
   e. Flanges: Class 150, ANSI B16.5, forged carbon steel, ASTM A105, slip-on
   f. Nipples: ASTM A733 made of ASTM A53, Schedule 80, black steel; seamless
   g. Reducers: Eccentric type (horizontal runs); concentric type (vertical runs)
7. Pipe – NPS 2-1/2 and Larger: Carbon steel, ASTM A53 or A106, Grade B, ERW or seamless, standard weight
   a. Fittings: Wrought steel, ASME B16.9, seamless, Class 150, and Schedule 40
   b. Joints: Butt-weld
   c. Elbows: Long radius
   d. Flanges: Class 150, ANSI B16.5, forged carbon steel, raised face, ASTM A105, weld neck
   e. Reducers: Eccentric type (horizontal runs); concentric type (vertical runs)

C. Feedwater:

8. Pipe NPS 2 and Smaller: Carbon steel, ASTM A53 or A106, ERW; Schedule 40
   a. Fittings: Class 150 malleable iron, ANSI B16.3
   b. Joints: Threaded
   c. Unions: Class 150 malleable iron, ANSI B16.3
   d. Reducers: Concentric type
9. Pipe NPS 2-1/2 and Larger: Carbon steel, ASTM A53 or A106, ERW, Schedule 40
   a. Fittings: Class 150 malleable iron, ANSI B16.3
   b. Joints: Welded

c. Unions: Class 150 carbon steel, MSS SP-87
d. Flanges: Forged steel weld neck or slip-on, ANSI B16.5
e. Reducers: Concentric type

D. Blowdown Water:
1. Pipe – NPS 2 and Smaller: Carbon steel, ASTM A53 or A106, Grade B, seamless, Schedule 80
   a. Fittings: Forged steel, ASME B16.11, Class 150
   b. Joints: Socket-weld or threaded
   c. Unions: Forged steel, ASTM A105, socket weld, 3000 lb, and stainless steel seats
   d. Gaskets: Flexitallic Style CG, API 601 spiral wound 304SS with Grafoil Fill, or CONTRACTOR-approved equal
   e. Flanges: Class 150, ANSI B16.5, forged carbon steel, ASTM A105, slip-on
   f. Nipples: ASTM A733 made of ASTM A53, Schedule 80, black steel; seamless
   g. Reducers: Concentric type
2. Pipe – NPS 2-1/2 and Larger: Carbon steel, ASTM A53 or A106, Grade B, ERW or seamless, standard weight
   a. Fittings: Wrought steel, ASME B16.9, seamless, Class 150, and Schedule 40
   b. Joints: Butt-weld
   c. Elbows: Long radius
   d. Flanges: Class 150, ANSI B16.5, forged carbon steel, raised face, ASTM A105, weld neck
   a. Reducers: Concentric type

E. Flexible Hose Connectors: Stainless-steel bellows with woven, flexible, stainless steel, wire-reinforced, double-braided protective jacket; 500-psig minimum working pressure at 500°F maximum operating temperature (provide de-rating table), and comply with B31.3. Connectors shall have Class 150, stainless steel, raised face flanged connections (at least one end lap joint) to match adjoining piping and shall be of sufficient length to allow minimum 3 inch centerline-to-centerline misalignment to accommodate maximum thermal expansion.

F. Welding Materials: Comply with ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

2.3 VALVES

A. Gate, globe, check, ball, and butterfly valves are specified in Division 15, section “Valves.”

B. Refer to Part 3, “Valve Applications” article for applications of each valve.

2.4 PRESSURE-REDUCING VALVES PCV-110S AND PCV-110D

A. Sized for full steam flow capacity as follows:
1. 3,000 lb/hr saturated steam
2. 100 psig inlet
3. 45 psig outlet (factory set)

B. Valve Characteristics: Cast steel or iron valve, Class 150 or 250 flanged ends, adjustable pressure range and positive shutoff, hardened stainless steel trim with replaceable valve head and seat, integral pressure gauges, and stainless steel tubing.

C. Manufacturers: Spirax Sarco 25P or CONTRACTOR-approved equal

2.5 STEAM TRAPS

A. Thermodynamic and Float Traps: Cast iron or stainless-steel body; maximum operating pressure of 600 psig; stainless-steel disc and seat; threaded ends, integral strainer, blowdown valve, and insulating cover.

B. Make and Model: Spirax Sarco TD42L with insulcap, FT-30, or CONTRACTOR-approved equal.

2.6 THERMOSTATIC AIR VENTS

A. Install at high points to automatically release accumulated air.

B Cast-iron or brass body, self-adjusting balanced-pressure, stainless-steel bellows, head, and seat, maximum operating pressure 250 psig, renewable internals, bolted cap, threaded ends.

C. Make and Model: Spirax Sarco VS204 or CONTRACTOR-approved equal.

2.7 MOISTURE SEPARATORS

A. Steel Body: Saturated steam service; steel body (Class 150) or cast-iron body (Class 250); code stamped, flanged ends, with level gauge glass, vent and drain valves (gate type), and internal baffle. Drain shall have float-operated trap and wye-strainer for automatic discharge.

B. Make and Model: Spirax Sarco S4A or CONTRACTOR-approved equal.

2.8 STRAINERS

A. Wye-Pattern Strainers: Class 150 or Class 250 as applicable per the drawings, saturated steam service; cast-steel body (Class 150) or cast-iron body (Class 250); stainless-steel screen, 1/32-inch perforations for NPS 3 and smaller and 1/8-inch perforations for pipe sizes larger than NPS 3; flanged ends, with drain valve (gate type).

B. Make and Model: Spirax Sarco Fig. 34 or CONTRACTOR-approved equal.

2.9 LABELS

A. “CAUTION” labels shall be installed on hot piping outer insulation jacket every 10 ft to warn of potentially hot conditions.

PART 3 - EXECUTION

3.1 WELDING OF STEAM PIPING

A. Steam piping and fittings shall be welded and fabricated in accordance with the latest edition of ASME/ANSI codes, and the latest editions of Standards B31.3 for all systems. Machine beveling in shop is preferred. Field beveling may be done by flame cutting to recognized standards.

B. Ensure complete penetration of deposited metal with base metal. Provide filler metal suitable for use with base metal. Keep inside of fittings free from globules of weld metal. All welded pipe joints shall be made by the fusion welding process, employing a metallic arc, or gas welding process. All pipes shall have the ends beveled and all joints shall be aligned true before welding. Except as specified otherwise, all changes in direction, intersection of lines, reduction in pipe size and the like shall be made with factory-fabricated welding fittings. Mitering of pipe to form elbows, notching of straight runs to form tees, or any similar construction is not permitted.

C. Align piping and equipment so that no part is offset more than 1/16 inch. Set all fittings and joints square and true, and preserve alignment during welding operation. Use of alignment rods inside pipe is prohibited.

D. No weld shall project into the pipe so as to restrict it. Tack welds, if used, must be of the same material and made by the same procedure as the completed weld. Otherwise, remove tack welds during welding operation.

E. Remove all split, bent, flattened, or otherwise damaged piping from the project site.

F. Remove dirt, scale, and other foreign matter from the inside of piping, by swabbing or flushing, prior to the connection of piping sections, fittings, valves, or equipment.

G. Schedule 40 pipe shall be welded with not less than three passes including one stringer/root, one filter and one lacer. Schedule 80 pipe shall be welded with not less than four passes, including one stringer/root, two filler, and one lacer. In all cases, however, the weld must be filled before the cap weld is added.

H. Steam trap assemblies can be threaded.

3.2 VALVE APPLICATIONS

A. General-Duty Valve Applications: Unless otherwise indicated, use the following valve types:
   1. Shutoff Duty: Gate or butterfly valves
   2. Throttling Duty: Globe or needle valves

B. Install valves as indicated on the drawings and where recommended by equipment manufacturer.

C. Refer to Division 15, section “Valves.”

3.3 STEAM-TRAP APPLICATIONS

A. Thermodynamic or Float Traps: Steam main and riser drip legs, and branch lines and all low points.

3.4 PIPING INSTALLATIONS

A. Refer to Division 15, section “Basic Mechanical Materials and Methods,” for basic piping installation requirements.

B. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

C. Install steam supply piping at a minimum uniform grade of 1/8 inch per foot in a downward direction of steam flow, where practical.

D. All pipes shall be run parallel to or at right angles to walls, beams, or columns, unless otherwise approved by the CONTRACTOR. Pipe shall run as direct as possible, avoiding unnecessary offsets, and maintaining maximum headroom. Shortcut diagonal methods will not be allowed.

E. Pipe drawings are to be considered schematic and are not intended to indicate all changes in directions, elevations, and necessary fittings to be furnished and installed. Pipe and fittings shall be installed so that all pipe, insulation, valves, and other connections completely clears all nearby structures and piping.

F. Underground piping shall be encased in polyethylene wrap, according to ASTM A674 or AWWA C105.

G. In horizontal pipe runs, reduce pipe sizes using eccentric reducer fitting installed with level side down (steam system); and concentric reducers for all other systems. Concentric reducers can be used in vertical pipe runs.

H. Unless otherwise indicated, install branch connections to main headers using 90° weldolets fittings in main pipe, with the takeoff coming out the top of the main pipe. Use of other than 90° tee fittings is permissible if 90 degrees fittings are impractical.

I. Install threaded flanges or unions in piping NPS 2 and smaller adjacent to each valve, at final connections to wells, at equipment connections, and elsewhere as indicated.

J. Install flanges in piping NPS 2-1/2 and larger at final connections to wells, at equipment connections, and elsewhere as indicated.

K. Install strainers on supply side of each pressure-reducing valve, solenoid valve, traps, and elsewhere as indicated. Install nipple and gate valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blow off connection for strainers. Strainer may be integral with the steam trap device.

L. All piping shall be supported by means of approved hangers and supports.

M. Pipes shall be arranged to allow for expansion and contraction.

N. Install pipe guides for proper direction of expansion and contraction.

O. For steam system, install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, ahead of pressure regulators, control valves, isolation valves, and pipe bends.
   1. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 200 ft where pipe is pitched down in direction of steam flow.
   2. Size drip legs at vertical risers, same size as pipe, and extend beyond riser. Size drip legs at other locations to be same diameter as main. In steam mains NPS 6 and larger, drip leg size can be reduced, but to no less than NPS 4.
   3. Install steam traps on drip legs.

P. For steam, water, and natural gas piping, install vents at high points such as risers, and drains at low points.

Q. Pipe supports shall be structurally capable of carrying the pipe or pipes supported by them, and shall be capable of vertical adjustment after pipe installation.

R. Install steam traps in accessible locations as close as possible to isolation valves.

S. Install steam traps in accordance with manufacturer’s written instructions.

T. On upstream side of steam trap, install two isolation valves, and a bleed valve (between the isolation valves).

3.5 REGULATING VALVE INSTALLATION

A. Install regulating valves in readily accessible locations for maintenance and inspection.

B. Install threaded nipples and flanges on low and high-pressure side of each regulating valve having threaded-end connections.

C. Install pressure gauges on low-pressure side of each pressure-reducing valve.

D. Install temperature gauge on regulated side of each temperature regulating valve.

E. Install pressure gauges downstream of each globe valve (not required for bypass lines).

F. Install strainers upstream for each regulating valve.

3.6 FLOW METER INSTALLATION

A. Install lengths of straight pipe upstream and downstream from meters, according to flow meter manufacturer's instructions.

B. Install strainer on upstream side of flow meter per manufacturer’s instructions.

3.7 PIPE SUPPORTS

A. Supports and anchor devices are specified in Division 15, section "Hangers and Supports."

B. Install supports with the following maximum spacing unless other spacing is allowed or required by the stress analysis to account for valves, risers, and direction changes:

1. NPS 1/2 inch: Maximum span 7 ft
2. NPS 3/4: Maximum span 7 ft
3. NPS 1: Maximum span 7 ft
4. NPS 1-1/4 inch: Maximum span 7 ft
5. NPS 1-1/2: Maximum span 9 ft
6. NPS 2: Maximum span 10 ft
7. NPS 2-1/2: Maximum span 11 ft
8. NPS 3: Maximum span 12 ft
9. NPS 4: Maximum span 14 ft
10. NPS 5: Maximum span 15 ft
11. NPS 6: Maximum span 17 ft
12. NPS 8: Maximum span 19 ft
13. NPS 10: Maximum span 22 ft

3.8 PIPE JOINT CONSTRUCTION

A. Refer to Division 15, section "Basic Mechanical Materials and Methods," for joint construction requirements for threaded, welded, and flanged joints.

3.9 FIELD QUALITY CONTROL

A. Perform visual and radiography inspections as follows:

1. For Category D fluid service systems – visual inspections to the satisfaction of the code qualified examiner; no radiography inspections required.
2. For normal fluid service systems – visual inspections 5 percent fabrication and 100 percent longitudinal welds; radiography inspection 5 percent circumferential welds and miter groove welds of each welder.
3. For non-code fluid service systems – no visual inspections required; no radiography inspections required.
4. The SUBCONTRACTOR is responsible for all testing and shall notify the CONTRACTOR at least FIVE working days in advance of scheduled tests.

B. Prepare Category D piping according to ASME B31.3 and as follows:

1. Submit test procedure with test gauge calibration information to the CONTRACTOR at least 10 working days in advance of scheduled test.
2. Leave joints, including welds, uninsulated and exposed for examination during test.
3. Flush system with clean water. Clean strainers.
4. Isolate equipment and instruments from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment and wells.
5. Remove in-line flow meters and regulators unless allowed by manufacturer to be pressure tested, and install flanged pipe spools.

6. Install test safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
7. Install calibrated test pressure gauges at each end of the test boundary. Gauges shall have minimum accuracy of ±0.5 percent with range between 1.5 and 2.0 times test pressure.

C. Perform the following tests on Category D piping:
1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another approved liquid that is safe for workers and compatible with piping may be used. Use of air is not allowed.
2. While filling system, use vents installed at high points of system to release trapped air. Use drip legs or drains installed at low points for complete draining of liquid. If necessary, provide alternate means for removing all trapped air so that piping can be completely filled with test media.
3. Connect pressure source, and raise initial pressure to 25 psig. Inspect for leaks.
4. Raise pressure in no more than 50 psig increments and confirm no evidence of leakage before proceeding to the next increment.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design pressure. Test pressure shall not exceed maximum pressure for any component in system under test. Pressurize system to test pressure. Then isolate test source and let stand for 1 hour to equalize temperature. After 1 hour, check pressure. If pressure has dropped more than 1 percent, refill system to test pressure and repeat 1 hour equalization time. Hold for 10 minutes with less than 1 percent drop in pressure. If pressure drop is less than 1 percent, then record start pressure, temperature, and time (all test gauges).
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

3.10 CLEANING

A. Flush steam piping with clean water. Remove and clean or replace strainer screens.

END OF SECTION

SECTION 26 00 00 – ELECTRICAL

PART 1 GENERAL

1.1 SUMMARY

A. Provide electrical systems.

1.2 SUBMITTALS

A. Product Data: Submit manufacturer's product data and installation instructions for each material and product used.

B. Shop Drawings: Submit shop drawings indicating material characteristics, details of construction, connections, and relationship with adjacent construction.

C. Operation and Maintenance Data: Submit manufacturer's operation and maintenance data, including operating instructions, list of spare parts, and maintenance schedule.

1.3 QUALITY ASSURANCE

A. Comply with governing codes and regulations. Provide products of acceptable manufacturers, which have been in satisfactory use in similar service for three years. Use experienced installers. Deliver, handle, and store materials in accordance with manufacturer's instructions.

B. Arrangement of systems indicated on the drawings is diagrammatic and indicates the minimum requirements for electrical work. Site conditions shall determine the actual arrangement of conduits, boxes, and similar items. Take field measurements before fabrication. Be responsible for accuracy of dimensions and layout.

C. Comply with the National Electrical Code and applicable local regulations.

D. Include primary service, transformers, distribution center, grounding, power and lighting panels, wiring, outlet boxes, receptacles, lighting fixtures, switches, conduits, raceways, and all accessories.

E. Provide telephone and data outlets with cut out, box, and pull string only.

F. Modify and extend existing service to accommodate new work.

G. Coordinate schedule of data outlet completion with Owner's communications requirements and installer as applicable.

PART 2 PRODUCTS

2.1 MATERIALS

A. Electrical Systems:
   1. Manufacturers: Subject to compliance with requirements.
   2. Application: Exterior lighting.
   3. Type: Instrumentation and control for electrical systems.
      a. Power monitoring and control.
      b. Lighting control devices.
      c. Photoelectric switches.
   4. Type: Wiring devices.
      a. Receptacles.
      b. Finish plates.
   5. Type: Lighting.
      a. Area lighting.
   6. Connected Loads: Suitable for service.
      a. Site lighting.
      b. Convenience power.
   7. Components: Suitable for service.
      a. Cables, conduit, and tubing.
      b. Grounding and bonding devices.
      c. Hangers and supports.
      d. Raceways, boxes, and cabinets.
      e. Cable trays.
      f. Vibration and seismic controls.
      g. Identification devices and warning labels.
      h. Service entrance components.
      i. Switchboards.
      j. Low-voltage power switchgear.
      k. Grounding components.
      l. Transformers.
      m. Overcurrent protective devices.
      n. Panelboards.
      o. Fuses.
   8. Electrical Standards.
      a. Code: NFPA 70 National Electrical Code.
      b. HID Fixtures: UL 1572; ballasts, UL 1029; instant restrike device.
      c. Lamps: ANSI Standards, C78 series.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install materials and systems in accordance with manufacturer's instructions and approved submittals. Install materials in proper relation with adjacent construction and with uniform appearance for exposed work. Coordinate with work of other sections. Comply with applicable regulations and building code requirements.

B. Comply with National Electrical Code and building code requirements. Maintain continuity of circuits required to supply new or existing equipment in service.

C. Test all systems for proper operation. Restore damaged finishes. Clean and protect work from damage.

D. Instruct Owner's personnel in proper operation of systems.

END OF SECTION

SECTION 26 05 00 – COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.1 SUMMARY

A. Provide common work results for electrical systems.

1.2 SUBMITTALS

A. Product Data: Submit manufacturer's product data and installation instructions for each material and product used.

B. Shop Drawings: Submit shop drawings indicating material characteristics, details of construction, connections, and relationship with adjacent construction.
   1. Shop drawings shall be prepared and stamped by a qualified engineer licensed in the jurisdiction of the project.

C. Operation and Maintenance Data: Submit manufacturer's operation and maintenance data, including operating instructions, list of spare parts and maintenance schedule.

1.3 QUALITY ASSURANCE

A. Comply with governing codes and regulations. Provide products of acceptable manufacturers that have been in satisfactory use in similar service for three years. Use experienced installers. Deliver, handle, and store materials in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 MATERIALS

A. Common Work Results for Electrical:
   1. Manufacturers: Subject to compliance with requirements.
   2. Application: Locations indicated.
   3. Sustainable Design: Commissioning.
   4. Low-Voltage Cables:
      a. Armored Cable: UL Types AC.
      b. Metal-Clad Cable in Cable Trays: UL Type MC.
      c. Portable Cord for Flexible Pendant Leads to Outlets and Equipment: UL Type S.
      d. Fiber Optic Cables: Single channel low-loss glass type.
      e. 7.Wire Components:
      f. Conductors, No. 10 AWG and Smaller: Solid.
      g. Conductors, No. 8 AWG and Larger: Stranded.
      h. Insulation: THW, THHN/THWN or XHHW as applicable.
      i. Jackets: Factory-applied nylon or PVC.

j. Conductor Material: Copper.
k. Conductor Material: Copper-clad aluminum.
l. Conductor Material: Aluminum.

5. Metal Conduit and Tubing:
   a. Rigid Steel Conduit: ANSI C80.1.
   b. Electrical Metallic Tubing (EMT) and Fittings: ANSI C80.3.
   c. Liquidtight Flexible Metal Conduit and Fittings: UL 360.
6. Nonmetallic Conduit and Ducts:
   a. Underground PVC and ABS Plastic Utilities Duct: NEMA TC 6.
   b. PVC and ABS Plastic Utilities Duct Fittings: NEMA TC 9.
   c. Liquidtight Flexible Nonmetallic Conduit and Fittings: UL 1660.
7. Boxes and Fittings:
   a. Cabinet Boxes: UL 50, sheet steel, NEMA 1.
   b. Pull and Junction Boxes: UL 50, steel boxes.
   c. Metal Outlet, Device and Small Wiring Boxes: UL 514A and OS 1.
   d. Nonmetallic Outlet, Device and Small Wiring Boxes: NEMA OS 2.
8. Raceway Accessory Materials:
   a. Conduit Bodies: NEC requirements.
   b. Wireways: NEC requirements.
   c. Surface Raceways, Metallic: Galvanized steel, with snap-on covers.
   d. Surface Raceways, Nonmetallic: Rigid PVC, UL 94.
9. Cable Trays:
   a. Materials: Mill galvanized steel.
   b. Materials: Hot-dip galvanized steel.
   c. Materials: PVC-coated steel.
   d. Configuration: Ladder type, trough-type, solid-bottom type, channel type.
   e. Covers: Solid type, louvered type, and ventilated-hat type.
10. Components: Suitable for service.
   a. Cables, conduit, and tubing.
   b. Grounding and bonding devices.
   c. Hangers and supports.
   d. Raceways, boxes, and cabinets.
   e. Cable trays.
   f. Vibration and seismic controls.
   g. Identification devices and warning labels.
   h. Service entrance components.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install materials and systems in accordance with manufacturer's instructions and approved submittals. Install materials in proper relation with adjacent construction and with uniform appearance for exposed work. Coordinate with work of other sections. Comply with applicable regulations and code requirements. Provide proper clearances for servicing.

B. Maintain indicated fire ratings of walls, partitions, ceilings, and floors at penetrations. Seal with firestopping to maintain fire rating.

C. Clearly label and tag all components.

D. Test and balance all systems for proper operation.

E. Restore damaged finishes. Clean and protect work from damage.

F. Instruct Owner's personnel in proper operation of systems.

END OF SECTION

SECTION 26 05 04 – BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts maximum).
   b. AB 1, Molded Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures.
   c. ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 Volts.
   d. ICS 5, Industrial Control and Systems: Control Circuit and Pilot Devices.
   e. KS 1, Enclosed and Miscellaneous Distribution Switches (600 Volts Maximum).
2. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
3. Underwriters Laboratories Inc. (UL):
   a. 98, Standard for Enclosed and Dead-Front Switches.
   b. 248, Standard for Low Voltage Fuses.
   c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
   d. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   e. 508, Standard for Industrial Control Equipment.
   f. 943, Standard for Ground-Fault Circuit-Interrupters.
   g. 1059, Standard for Terminal Blocks.
   h. 1479, Fire Tests of Through-Penetration Fire Stops.

1.02 SUBMITTALS

A. Action Submittals:

1. Provide manufacturers’ data for the following:
   a. Control devices.
   b. Control relays.
   c. Circuit breakers.
   d. Fused switches.
   e. Nonfused switches.
   f. Timers.
   g. Fuses.
   h. Magnetic contactors.
   i. Circuit Breakers for existing Panelboards/MCCs.
   j. Transformers.
   k. Enclosures: Include enclosure data for products having enclosures.

2. Panelboards:
   a. Manufacturer’s data sheets for each type of panelboard/switchboard, protective device, accessory item, and component.
   b. Manufacturer’s shop drawings including dimensions and layout.

1.03 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts and special tools:

   1. Fuses, 0 to 600 Volts: Six of each type and each current rating installed.

PART 2 - PRODUCTS

2.01 GENERAL

A. Products shall comply with all applicable provisions of ANSI.NFPA 70-2002.
B. Like Items of Equipment: End products of one manufacturer in order to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer’s service.
C. Equipment Finish: Manufacturer's standard finish color, except where specific color is indicated.

2.02 MOLDED CASE CIRCUIT BREAKER THERMAL MAGNETIC AND ELECTRONIC, LOW VOLTAGE

A. General:

   1. Type: Molded case.
   2. Trip Ratings: 15-3000 amps.
   3. Voltage Ratings: 120, 240, 277, 480, and 600V ac.
   4. Suitable for mounting and operating in any position.
   5. NEMA AB 1 and UL 489.

B. Operating Mechanism:

   1. Over-center, trip-free, toggle type handle.
   2. Quick-make, quick-break action.
   3. Locking provisions for padlocking breaker in open position.
   4. ON/OFF and TRIPPED indicating positions of operating handle.
   5. Operating handle to assume a center position when tripped.

C. Trip Mechanism:

   1. Individual permanent thermal and magnetic trip elements in each pole.
   2. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
   3. Two and three pole, common trip.

4. Automatically opens all poles when overcurrent occurs on one pole.
5. Test button on cover.
6. Calibrated for 40 degrees C ambient, unless shown otherwise.
7. Do not provide single-pole circuit breakers with handle ties where multi-pole circuit breakers are shown.
8. Electronic trip units to have LS/I adjustable functions for frames less than 1000 amps and LSIG adjustable functions for frames 1000 amps or greater.

D. Short Circuit Interrupting Ratings:

1. Not less than the following RMS symmetrical currents for the indicated trip ratings:
   a. Up to 100A, less than 250V ac: 10,000 amps.
   b. Up to 100A, 250-600V ac: 65,000 amps.
   c. Over 100A: 65,000 amps.

E. Equipment Ground Fault Interrupter (EGFI): Where indicated and for Heat Trace circuits, equip breaker specified above with ground fault sensor and rated to trip on 30-mA ground fault (UL-listed for equipment ground fault protection).

F. Magnetic Only Type Breakers: Where shown; instantaneous trip adjustment which simultaneously sets magnetic trip level of each individual pole continuously through a 3X to 10X trip range.

G. Accessories: Shunt trip, auxiliary switches, handle lock ON devices, mechanical interlocks, key interlocks, unit mounting bases, double lugs as shown or otherwise required. Shunt trip operators shall be continuous duty rated or have coil-clearing contacts.

H. Connections:

1. Supply (line side) at either end.
2. Mechanical wire lugs, except crimp compression lugs where shown.
3. Lugs removable/replaceable for breaker frames greater than 100 amperes.
4. Suitable for 75 degrees C rated conductors without derating breaker or conductor ampacity.

I. Enclosures for Independent Mounting:

1. See Article Enclosures.
2. Service Entrance Use: Breakers in required enclosure and required accessories shall be UL 489 listed.
3. Interlock: Enclosure and switch shall interlock to prevent opening cover with switch in the ON position. Provide bypass feature for use by qualified personnel.

2.03 FUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

A. UL 98 listed for use and location of installation.

B. NEMA KS 1.

C. Short Circuit Rating: 200,000 amps RMS symmetrical with Class R, Class J, or Class L fuses installed.

D. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

E. Connections:

1. Mechanical lugs, except crimp compression lugs where shown.
2. Lugs removable/replaceable.
3. Suitable for 75 degrees C rated conductors at NEC 75 degrees C ampacity.

F. Fuse Provisions:

1. 30-amp to 600-amp rated shall incorporate rejection feature to reject all fuses except Class R.
2. 601-amp rated and greater shall accept Class L fuses, unless otherwise shown.

G. Enclosures: See Article Enclosures.

H. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

2.04 NONFUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

A. NEMA KS 1.

B. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

C. Lugs: Suitable for use with 75 degrees C wire at NEC 75 degrees C ampacity.

D. Enclosures: See Article Enclosures.

E. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

2.05 FUSE, 250-VOLT AND 600-VOLT

A. Power Distribution, General:

1. Current-limiting, with 200,000 ampere rms interrupting rating.
2. Provide to fit mountings specified with switches.
3. UL 248.

B. Power Distribution, Ampere Ratings 1 Amp to 600 Amps:

1. Class: RK-1.
2. Type: Dual element, with time delay.
3. Manufacturers and Products:

a. Bussmann; Types LPS-RK (600 volts) and LPN-RK (250 volts).
b. Littelfuse; Types LLS-RK (600 volts) and LLN-RK (250 volts).
c. Or as approved

C. Power Distribution, Ampere Ratings 601 Amps to 6,000 Amps:

1. Class: L.
2. Double O-rings and silver links.
3. Manufacturers and Products:
   a. Bussmann: Type KRP-C
   b. Littelfuse, Inc.: Type KLPC
   c. Or as approved

D. Cable Limiters:

1. 600V or less; crimp to copper cable, bolt to bus or terminal pad.
2. Manufacturer and Product: Bussmann; K Series.

E. Ferrule:

1. 600V or less, rated for applied voltage, small dimension.
2. Ampere Ratings: 1/10 amp to 30 amps.
3. Dual-element time-delay, time-delay, or non-time-delay as required.
4. Provide with blocks or holders as indicated and suitable for location and use.
5. Manufacturers:
   a. Bussmann
   b. Littelfuse, Inc.
   c. Or as approved

2.06 TERMINAL BLOCK, 600 VOLTS

A. UL 486E and UL 1059.

B. Size components to allow insertion of necessary wire sizes.

C. Capable of termination of control circuits entering or leaving equipment, panels, or boxes.

D. Screw clamp compression, dead front barrier type, with current bar providing direct contact with wire between compression screw and yoke.

E. Yoke, current bar, and clamping screw of high strength and high conductivity metal.

F. Yoke shall guide all strands of wire into terminal.

G. Current bar shall ensure vibration-proof connection.

H. Terminals:

1. Capable of wire connections without special preparation other than stripping.
2. Capable of jumper installation with no loss of terminal or rail space.

3. Individual, rail mounted.

I. Marking system, allowing use of preprinted or field-marked tags.

J. Manufacturers:

1. Phoenix Contact
2. Allen-Bradley
3. Weidmuller
4. Or as approved

2.07 LIGHTING AND POWER DISTRIBUTION PANELBOARD

A. NEMA PB 1, NFPA 70, and UL 67.

B. Panelboards and Circuit Breakers: Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

C. Short-Circuit Current Equipment Rating: Fully rated; series connected unacceptable.

D. Rating: Applicable to a system with available short-circuit current of 42,000 amperes or the indicated value amperes rms symmetrical at 208Y/120 or 120/240 volts and 14,000 amperes or the indicated value amperes rms symmetrical at 480Y/277 volts.

E. Cabinet:

1. NEMA 250, Type 1.
2. Material: Code-gauge, hot-dip galvanized sheet steel with reinforced steel frame.
3. Wiring Gutter: Minimum 4-inch square; both sides, top and bottom.
4. Front: Fastened with adjustable clamps.
   a. Trim Size: As required by mounting.
   b. Finish: Manufacturer’s standard.
5. Interior:
   a. Factory assembled; complete with circuit breakers.
   b. Spaces: Cover openings with easily removable metal cover.
6. Door Hinges: Concealed.
7. Locking Device:
   a. Flush type.
   b. Doors Over 30 Inches in Height: Multipoint.
   c. Identical keylocks, with two milled keys each lock.
8. Circuit Directory: Metal frame with transparent plastic face and enclosed card on interior of door.

F. Bus Bar:

1. Material: Copper full sized throughout length.
2. Neutral: Insulated, rated same as phase bus bars with at least one terminal screw for each branch circuit.
3. Ground: Copper, installed on panelboard frame, bonded to box with at least one terminal screw for each circuit.
4. Lugs and Connection Points:

a. Suitable for either copper or aluminum conductors.
b. Solderless main lugs for main, neutral, and ground bus bars.
c. Subfeed or through-feed lugs as shown.

G. Circuit Breakers:

1. UL 489.
2. Thermal-magnetic, quick-make, quick-break, molded case, of indicating type showing ON/OFF and TRIPPED positions of operating handle.
3. Type: Bolt-on circuit breakers in all panelboards.
4. Multipole circuit breakers designed to automatically open all poles when an overload occurs on one pole.
5. Do not use tandem or dual circuit breakers in normal single-pole spaces.

H. Surge Protection:

1. Integral to panelboard.
2. Surge Current Rating: 120kA, minimum.
3. Connection: Bus.
4. Location: Panelboard interior.

I. Manufacturers:

1. General Purpose Panelboards:
   a. Eaton/Cutler-Hammer.
   b. Schneider Electric/Square D.
   c. General Electric.
   d. Or as approved.
2. Lighting Control Panelboards:
   a. Eaton/Cutler-Hammer; Pow-R-Command 25.
   b. Schneider Electric/Square D.
   c. General Electric.
   d. Or as approved.

2.08 SWITCH, MOTOR-RATED

A. Type: Two- or three-pole, manual motor starting/disconnect switch without overload protection.

B. Enclosure/Mounting and Rating:

1. General Purpose:
   a. Totally enclosed snap-action switch. Quick-make, slow-break design with silver alloy contacts. Listed UL 508.
   b. General Purpose Rating: 30 amperes, 600V ac.
   c. Minimum Motor Ratings:
      1) 2 hp for 120V ac, single-phase, two-pole.
      2) 3 hp for 240V ac, single-phase, two-pole.
      3) 15 hp for 480V ac, three-phase, three-pole.
   d. Screw-type terminals.

e. Manufacturers:
   1) General Purpose:
      a) Bryant.
      b) Hubbell.

2.09 DRY TYPE POWER TRANSFORMERS (0- TO 600-VOLT PRIMARY)

A. Type: Self-cooled, two-winding.

B. UL 1561 and NEMA ST 20.

C. Insulation Class, Temperature Rise, and Impedance: Manufacturer’s standard.

D. Core and Coil:

1. 30 kVA or Less: Encapsulated.
2. 37.5 kVA and Larger: Varnish impregnated.

E. Enclosure:

1. 30 kVA or Less: NEMA 250, Type 3R, nonventilated.
2. 37.5 kVA and Larger: NEMA 250, Type 2, ventilated with drip/weather shield for outdoor use.

F. Voltage Taps: Full capacity, 2-1/2 percent, two above and two below normal voltage rating.

G. Sound Level: Not to exceed NEMA ST 20 levels.

H. Vibration isolators to minimize and isolate sound transmission.

I. Manufacturers:

1. Eaton/Cutler-Hammer.
2. Schneider Electric/Square D.
3. General Electric.
4. Or as approved.

2.10 SURGE PROTECTIVE DEVICES (SPD) EQUIPMENT

A. General:

1. Units shall be suitable for the service voltage and configuration (phases and wires) shown.
2. Use equipment specified in this section where equipment manufacturer does not provide integral surge protective devices for equipment at the noted exposure locations.
3. Protection modes.
4. Normal, differential, and common.
5. Bipolar or bi-directional.
6. Ratings: Short-circuit current rating shall equal or exceed that of protected

distribution equipment. Surge Voltage Rating (SVR) shall not exceed those specified under UL 1449 for the associated nominal system voltage. Maximum Allowable Continuous Operating Voltage
(MCOV) shall be at least 115 percent of the nominal system voltage.

7. Unit shall be UL-listed.
8. Provide status indicators for unit ON-LINE and unit operation NORMAL.
9. Provide common alarm contact output.
10. Provide fusible disconnect switch (integral with SPD unit, where available) where not shown connected via branch circuit device of protected distribution equipment.
11. Minimum Enclosure Rating: NEMA 250, Type 2. Provide Type 4/4X for outdoor or wet locations.

B. Type 1 SPD:

1. Requirements: High surge current device designed for location/exposure Category C3, per IEEE C62.41. Provide surge current rating per phase as shown. Unit shall utilize symmetrically balanced Metal Oxide Varistor (MOV) technology.
2. Manufacturer and Product: Transtector; Model Aegis SP.

C. Type 2 SPD:

1. Requirements: Designed for critical loads at service equipment (Category C3/B3) or distribution panelboard (Category C2/B3) locations. Unit shall utilize voltage-matched Silicon Avalanche Suppressor Diode (SASD) technology. Unit shall utilize modular, plug-in suppressor design.
2. Manufacturer and Product: Transtector; Model Apex III (nonservice entrance distribution panelboard) or Apex IV (service equipment).

D. Type 3 SPD:

1. Requirements: Designed for noncritical loads at distribution panelboards with location/exposure Category C3. Unit shall utilize symmetrically balanced Metal Oxide Varistor (MOV) technology. Unit shall utilize modular, plug-in suppressor design.
2. Manufacturer and Product: Transtector; Model SPD.

2.11 SUPPORT AND FRAMING CHANNELS

A. Carbon Steel Framing Channel:

1. Material: Rolled, mild strip steel, 12-gauge minimum, ASTM A1011/A1011M, Grade 33.
2. Finish: Hot-dip galvanized after fabrication.

B. Paint Coated Framing Channel: Carbon steel framing channel with electro- deposited rust inhibiting acrylic or epoxy paint.

C. PVC Coated Framing Channel: Carbon steel framing channel with 40-mil polyvinyl chloride coating.

D. Stainless Steel Framing Channel: Rolled, ASTM A167, Type 316 stainless steel, 12-gauge minimum.

E. Extruded Aluminum Framing Channel:

1. Material: Extruded from Type 6063-T6 aluminum alloy.
2. Fittings fabricated from Alloy 5052-H32.

F. Nonmetallic Framing Channel:

1. Material: Fire retardant, fiber reinforced vinyl ester resin.
2. Channel fitting of same material as channel.
3. Nuts and bolts of long glass fiber reinforced polyurethane.

G. Manufacturers:

1. B-Line Systems, Inc.
2. Unistrut Corp.
3. Aickinstrut.
4. Or as approved.

2.12 FIRESTOPS

A. General:

1. Provide UL 1479 classified hourly fire-rating equal to, or greater than, the assembly penetrated.
2. Prevent the passage of cold smoke, toxic fumes, and water before and after exposure to flame.
3. Sealants and accessories shall have fire-resistance ratings as established by testing identical assemblies in accordance with ASTM E814, by Underwriters Laboratories Inc., or other testing and inspection agency acceptable to authorities having jurisdiction.

2.13 ENCLOSURES

A. Finish: Sheet metal structural and enclosure parts shall be completely painted using an electrodeposition process so interior and exterior surfaces as well as bolted structural joints have a complete finish coat on and between them.

B. Color: Manufacturer’s standard color (gray) baked-on enamel, unless otherwise shown.

C. Barriers: Provide metal barriers within enclosures to separate wiring of different systems and voltage.

D. Enclosure Selections: Except as shown otherwise, provide electrical enclosures according to the following table:

ENCLOSURES			
Location	**Finish**	**Environment**	**NEMA 250 Type**
Indoor and Outdoor	Any	Wet	4
Indoor and Outdoor	Any	Denoted “WP”	3R

PART 3 - EXECUTION

3.01 GENERAL

A. Install equipment in accordance with manufacturer’s recommendations.

3.02 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

A. Unless otherwise shown, install heavy-duty, oil-tight type in nonhazardous, indoor, dry locations, including motor control centers, control panels, and individual stations.

B. Unless otherwise shown, install heavy-duty, watertight and corrosion-resistant type in nonhazardous, outdoor, or normally wet areas.

3.03 PANELBOARDS

A. Install securely, plumb, in-line and square with walls.

B. Install top of cabinet 6 feet above floor for cabinets less than 4-feet tall, unless otherwise shown.

C. Provide typewritten circuit directory for each panelboard.

D. Cabinet Location/Type:

1. Indoor Dry: NEMA 250, Type 12.
2. Wet or Outdoor: NEMA 250, Type 3R, Outdoor.
3. Industrial Use in Areas Not Otherwise Classified: NEMA 250, Type 12, unless otherwise shown.

3.04 SWITCH, MOTOR RATED

A. Install with switch operation in vertical position such that toggle is in up position when ON.

B. Install within sight of motor when used as a disconnect switch.

C. Mounting Height: See Article Outlet and Device Boxes.

D. Enclosure Type:

1. General Purpose: See Articles Outlet and Device Boxes and Device Plates.

3.05 DRY TYPE POWER TRANSFORMERS (0- TO 600-VOLT PRIMARY)

A. Load external vibration isolator such that no direct transformer unit metal is in direct contact with mounting surface.

B. Provide moisture-proof flexible conduit for electrical connections.

C. Connect voltage taps to achieve (approximately) rated output voltage under normal plant load conditions.

D. Provide wall brackets where required.

3.06 SURGE PROTECTION DEVICES (SPD) EQUIPMENT

A. Install in accordance with manufacturer's instructions, including lead length, overcurrent protection, and grounding.

3.07 SUPPORT AND FRAMING CHANNEL

A. Install where required for mounting and supporting electrical equipment, raceway.

B. Channel Type:

1. Interior, Wet or Dry (Noncorrosive) Locations:
   a. Steel Raceway and Other Systems Not Covered: Carbon steel or paint coated.
2. Outdoor, Locations:
   a. Steel Raceway: Carbon steel or paint coated framing channel, except where mounted on aluminum handrail, then use aluminum framing channel.
   b. Aluminum Raceway and Other Systems Not Covered: Aluminum framing channel.

C. Paint cut ends prior to installation with the following:

1. Carbon Steel Channel: Zinc-rich primer.
2. Painted Channel: Rust-inhibiting epoxy or acrylic paint.
3. Nonmetallic Channel: Epoxy resin sealer.
4. PVC-Coated Channel: PVC patch.

3.08 FIRESTOPS

A. Install in strict conformance with manufacturer's instructions. Comply with installation requirements established by testing and inspecting agency.

B. Sealant: Install sealant, including forming, packing, and other accessory materials, to fill openings around electrical services penetrating floors and walls, to provide firestops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs.

END OF SECTION

SECTION 26 05 05 – CONDUCTORS

PART 1 - GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. Association of Edison Illuminating Companies (AEIC): CS 8, Specification for Extruded Dielectric Shielded Power Cables Rated 5 kV through 46 kV.
2. ASTM International (ASTM):
   a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   b. B3, Standard Specification for Soft or Annealed Copper Wire.
   c. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
   d. B496, Standard Specification for Compact Round Concentric- Lay-Stranded Copper Conductors.
3. Electronic Industries Alliance (EIA), Telecommunications Industry Association (TIA): TIA-568-B, Commercial Building Telecommunications Cabling Standard.
4. Insulated Cable Engineer's Association, Inc. (ICEA):
   a. S-58-679, Standard for Control Cable Conductor Identification.
   b. S-73-532, Standard for Control Cables.
   c. T-29-520, Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input of 210,000 Btu/hour.
5. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. 48, Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminations 2.5 kV through 765 kV
   b. 386, Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
   c. 404, Standard for Extruded And Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V.
6. National Electrical Manufacturers' Association (NEMA):
   a. CC 1, Electric Power Connectors for Substations.
   b. WC 57, Standard for Control, Thermocouple Extension, and Instrumentation Cables - ICEA S-73-532.
   c. WC 70, Standard for Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
   d. WC 71, Standard for Nonshielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy.
   e. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.
7. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 262, Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
8. Underwriters Laboratories Inc. (UL):
   a. 13, Standard for Safety Power-Limited Circuit Cables.
   b. 44, Standard for Safety Thermoset-Insulated Wires and Cables.

c. 62, Standard for Safety Flexible Cord and Cables.
d. 486A-486B, Wire Connectors.
e. 486C, Standard for Splicing Wire Connections.
f. 510, Standard for Safety Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
g. 854, Standard for Safety Service-Entrance Cables.
h. 1072, Standard for Safety Medium-Voltage Power Cables.
i. 1277, Standard for Safety Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
j. 1569, Metal Clad Cables.
k. 1581, Standard for Safety Reference Standard for Electrical Wires, Cables, and Flexible Cords.

1.02 SUBMITTALS

A. Action Submittals:

1. Wire and cable descriptive product information.
2. Wire and cable accessories descriptive product information.
3. Medium voltage (15-kV) cables, terminations, splices, and accessories.

B. Informational Submittals: Factory Test Reports.

1.03 QUALITY ASSURANCE

A. Provide the Work in accordance with ANSI.NFPA 70. Material and equipment shall be labeled or listed by a nationally recognized testing laboratory (NRTL).

B. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories Inc. shall conform to those standards and shall have an applied UL listing mark.

PART 2 - PRODUCTS

2.01 CONDUCTORS 600 VOLT RATED CABLE

A. Power Cable type shall be 600V Power C-L-X type MC-HL Cable

1. Aluminum Sheath, continuous, welded, corrugated with impervious PVC jacket.
2. Stranded copper. Aluminum conductors are not acceptable.
3. 90 Deg C Wet or Dry Rating.
4. Rated for Cable Tray Use – Sunlight Resistant – For Direct Burial.
5. Insulation: Type Cross-linked polyethylene with high dielectric strength. XHHW-2 insulation, unless otherwise shown on the Drawings.
6. Color Coding: # 6 AWG and smaller are color coded using base colors and tracers.# 4AWG and larger are printed number/color coded.
7. Bare stranded ground copper grounding conductor; meets or exceeds the requirements of NEC Table 250.122.
8. Manufacturers:

a. Okonite Co.
b. Southwire.
c. Or as approved

2.02 MEDIUM-VOLTAGE 15-KV INSULATED CABLE.

A. Submittals:

1. Submit product data for approval indicating cable and accessory construction, materials, and ratings. The following data shall be supplied by the subcontractor for each 15-kV cable: complete description of cable, including diameters over conductor, insulation, semicon insulation shield, and overall diameter and ampere rating per conductor based on an ambient temperature of 40°C and a copper temperature of 90°C or 105°C as specified.

2. Submit manufacturer's installation instructions. The following data shall be supplied by the subcontractor for each 15-kV cable: manufacturer's instructions for splices and terminations, factory high-potential test voltage, minimum duct-bend radii, maximum pulling tension, and maximum sidewall pressure.

3. Submit manufacturer's certificate that medium voltage cable meets or exceeds specified requirements.

4. Submit manufacturer’s product data for splices and terminations, and all accessories for all 15-kV cable.

B. Cable, 15,000 Volt, Three Conductor, Shielded

1. The cables specified on the drawings as 3/C-15 kV shall be three-conductor, shielded, solid-dielectric type rated for 105°C operation. The cables shall be listed by UL as Type MV-105 and have a 15,000-V rating.

2. The conductor shall be stranded copper, sized in accordance with the drawings. The insulation level shall be 133% of rated voltage with a minimum thickness of 220 mils. The insulation shielding shall be uncoated copper tape.

3. The cable shall have ethylene-propylene-rubber (EPR) insulation and be constructed in conformance with NEMA Standard WC-74 and AEIC Specification CS8.

4. All splicing and terminating materials shall be properly matched to the sizes and configurations of the cables specified. Outdoor kits shall be used for all outdoor installations.

5. Terminations and dead-end seals shall be made with 15-kV premolded termination kits, such as Raychem “HVT” – termination series kits, and “HVES” – end seal kits. Splices shall be made with heat-shrinkable splice kits, such as Raychem “HVS” – series kits.

6. All splicing and terminating materials must be installed in strict adherence to the manufacturer's instructions, and care must be exercised to keep the cable ends and insulating materials clean and dry during installation.

2.03 POWER AND CONTROL CABLE

B. Type 1, Multiconductor Control Cable/Instrumentation Cable:

1. Conductors:
   a. 16 AWG, seven-strand copper.
   b. Insulation: 15-mil PVC with 4-mil nylon.
   c. UL listed for cable tray, direct burial, and sunlight resistant.
   d. Conductor group bound with spiral wrap of barrier tape.
   e. Color Coded and numbers pairs or triads.
   f. As required – twisted, shielded pair with overall shield for noise rejection for process control, computer, or data log applications.

2. Cable: close-fitting, impervious, continuously welded and corrugated, aluminum sheath meeting UL 1569 with outer PVC flame-retardant jacket. UL listed as type MC-HL

3. Manufacturers:
   a. Okonite Co.
   b. Southwire
   c. Or as approved

C. Type 3, 16 AWG, Twisted, Shielded Pair, Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.

1. Outer Jacket: 45-mil nominal thickness.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
3. Dimension: 0.31-inch nominal OD.
4. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
   b. 20 AWG, seven-strand tinned copper drain wire.
   c. Insulation: 15-mil nominal PVC.
   d. Jacket: 4-mil nominal nylon.
   e. Color Code: Pair conductors, black and red.
5. Cable: close-fitting, impervious, continuously welded and corrugated, aluminum sheath meeting UL 1569 with outer PVC flame-retardant jacket. UL listed as type MC-HL

6. Manufacturers:
   a. Okonite Co.
   b. Alpha Wire Corp.
   c. Belden
   d. Or as approved

2.04 GROUNDING CONDUCTORS

A. Equipment: Stranded copper with green, Type XHHW, USE/RHH/RHW-XLPE, or THHN/THWN, insulation as noted on Drawings.

B. Grounding/Earth: Bare stranded copper as noted on Drawings.

2.05 ACCESSORIES FOR CONDUCTORS 600 VOLTS AND BELOW

A. Tape:

1. General Purpose, Flame Retardant: 7-mil, vinyl plastic, Scotch Brand 33+, rated for 90 degrees C minimum, meeting requirements of UL 510.
2. Flame Retardant, Cold and Weather Resistant: 8.5-mil, vinyl plastic, Scotch Brand 88.
3. Arc and Fireproofing:
   a. 30-mil, elastomer.
   b. Manufacturers and Products:
      1) 3M; Scotch Brand 77, with Scotch Brand 69 glass cloth tapebinder.
      2) Plymouth; 53 Plyarc, with 77 Plyglas glass cloth tapebinder.

B. Identification Devices:

1. Sleeve:
   a. Permanent, PVC, yellow or white, with legible machine-printed black markings.
   b. Manufacturers and Products:
      1) Raychem; Type D-SCE or ZH-SCE
      2) Brady, Type 3PS
      3) Or as approved
2. Heat Bond Marker:
   a. Transparent thermoplastic heat bonding film with acrylic pressure sensitive adhesive.
   b. Self-laminating protective shield over text.
   c. Machine printed black text.
   d. Manufacturer and Product: 3M Co.; Type SCS-HB.
3. Marker Plate: Nylon, with legible designations permanently hot stamped on plate.
4. Tie-On Cable Marker Tags:
   a. Chemical-resistant white tag.
   b. Size: 1/2 inch by 2 inches.
   c. Manufacturer and Product: Raychem; Type CM-SCE.
5. Grounding Conductor: Permanent green heat-shrink sleeve, 2-inch minimum.

C. Connectors and Terminations:

1. Nylon, Self-Insulated Crimp Connectors:
   a. Manufacturers and Products:
      1) Thomas & Betts; Sta-Kon

2) Burndy; Insulug
3) ILSCO
4) Or as approved

2. Nylon, Self-Insulated, Crimp Locking-Fork, Torque-Type Terminator:
   a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
   b. Seamless.
   c. Manufacturers and Products:
      1) Thomas & Betts; Sta-Kon
      2) Burndy; Insulink
      3) ILSCO; ILSCONS
      4) Or as approved

3. Self-Insulated, Freespring Wire Connector (Wire Nuts):
   a. UL 486C.
   b. Plated steel, square wire springs.
   c. Manufacturers and Products:
      1) Thomas & Betts
      2) Ideal; Twister
      3) Or as approved
4. Self-Insulated, Set Screw Wire Connector:
   a. Two piece compression type with set screw in brass barrel.
   b. Insulated by insulator cap screwed over brass barrel.
   c. Manufacturers:
      1) 3M Co.
      2) Thomas & Betts
      3) Marrette
      4) Or as approved

D. Cable Lugs:

1. In accordance with NEMA CC 1.
2. Rated 600 volts of same material as conductor metal.
3. Uninsulated Crimp Connectors and Terminators:
   a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
   b. Manufacturers and Products:
      1) Thomas & Betts; Color-Keyed
      2) Burndy, Hydent
      3) ILSCO
      4) Or as approved
4. Uninsulated, Bolted, Two-Way Connectors and Terminators:
   a. Manufacturers and Products:
      1) Thomas & Betts; Locktite
      2) Burndy; Quiklug
      3) ILSCO
      4) Or as approved

E. Cable Ties:

1. Nylon, adjustable, self-locking, and reusable.
2. Manufacturer and Product: Thomas & Betts; TY-RAP.

F. Heat Shrinkable Insulation:

1. Thermally stabilized cross-linked polyolefin.
2. Single wall for insulation and strain relief.
3. Dual Wall, adhesive sealant lined, for sealing and corrosion resistance.
4. Manufacturers and Products:
   a. Thomas & Betts; SHRINK-KON
   b. Raychem; RNF-100 and ES-2000
   c. Or as approved

2.06 PULLING COMPOUND

A. Nontoxic, noncorrosive, noncombustible, nonflammable, water-based lubricant; UL listed.

B. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.

C. Approved for intended use by cable manufacturer.

D. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.

E. Manufacturers:

1. Ideal Co.
2. Polywater, Inc.
3. Cable Grip Co.
4. Or as approved

2.07 WARNING TAPE

A. As specified in Section 26 05 33, Raceways and Boxes.

2.08 SOURCE QUALITY CONTROL

A. Conductors 600 volts and below: Test in accordance with applicable UL Standards and section 26 05 02, Basic Electrical Requirements.

PART 3 - EXECUTION

3.01 GENERAL

A. Conductor installation shall be in accordance with manufacturer's recommendations.

B. Conductor and cable sizing shown is based on copper conductors, unless noted otherwise.

C. Do not exceed cable manufacturer's recommendations for maximum pulling tensions and minimum bending radii.

D. Terminate all conductors and cables, unless otherwise indicated.

E. Tighten screws and terminal bolts in accordance with UL 486A-486B for copper conductors.

F. Cable Lugs: Provide with correct number of holes, bolt size, and center-to- center spacing as required by equipment terminals.

3.02 POWER CONDUCTOR COLOR CODING

A. Conductors 600 volts and below:

1. 6 AWG and Larger: Apply general purpose, flame retardant tape at each end and at accessible locations wrapped at least six full overlapping turns, covering an area 1-1/2 inches to 2 inches wide.
2. 8 AWG and smaller: Provide colored conductors.
3. Colors:

System	Conductor	Color
All Systems	Equipment Grounding	Green
240/120 Volts Single-Phase, Three-Wire	Grounded Neutral One Hot Leg Other Hot Leg	White Black Red
208Y/120 Volts Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Black Red Blue
240/120 Volts Three-Phase, Four-Wire Delta, Center Tap Ground on Single-Phase	Grounded Neutral Phase A High (wild) Leg Phase C	White Black Orange Blue
480Y/277 Volts Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Brown Orange Yellow
NOTE: Phase A, B, C implies direction of positive phase rotation.		

4. Tracer: Outer covering of white with an identifiable colored strip, other than green, in accordance with NFPA 70.

3.03 CIRCUIT IDENTIFICATION

A. Identify power, instrumentation, and control conductor circuits at each termination, and in accessible locations such as manholes, handholes, panels, switchboards, motor controllers, pull boxes, and terminal boxes.

B. Circuits appearing in Circuit Schedules: Identify using circuit schedule designations.

C. Circuits Not Appearing in Circuit Schedules:

1. Assign circuit name based on device or equipment at load end of circuit.
2. Where this would result in same name being assigned to more than one circuit, add number or letter to each otherwise identical circuit name to make it unique.

D. Method:

1. Conductors 3 AWG and Smaller: Identify with sleeves or heat bond markers.
2. Cables and Conductors 2 AWG and Larger:
   a. Identify with marker plates or tie-on cable marker tags.
   b. Attach with nylon tie cord.
3. Taped-on markers or tags relying on adhesives not permitted.

3.04 CONDUCTORS 600 VOLTS AND BELOW

A. Install minimum # 10 AWG or 12 AWG conductors for branch circuit power wiring in lighting and receptacle circuits.

B. Do not splice incoming service conductors and branch power distribution conductors 6 AWG and larger, unless specifically indicated or approved by Engineer.

C. Connections and Terminations:

1. Install wire nuts only on solid conductors. Wire nuts are not allowed on stranded conductors.
2. Install nylon self-insulated crimp connectors and terminators for instrumentation and control, circuit conductors.
3. Install self-insulated, set screw wire connectors for two-way connection of power circuit conductors 12 AWG and smaller.
4. Install uninsulated crimp connectors and terminators for instrumentation, control, and power circuit conductors 4 AWG through 2/0 AWG.
5. Install uninsulated, bolted, two-way connectors and terminators for power circuit conductors 3/0 AWG and larger.
6. Install uninsulated terminators bolted together on motor circuit conductors 10 AWG and larger.
7. Place no more than one conductor in any single-barrel pressure connection.
8. Install crimp connectors with tools approved by connector manufacturer.
9. Install terminals and connectors acceptable for type of material used.
10. Compression Lugs:
    a. Attach with a tool specifically designed for purpose. Tool shall provide complete, controlled crimp and shall not release until crimp is complete.
    b. Do not use plier type crimpers.

D. Do not use soldered mechanical joints.

E. Splices and Terminations:

1. Insulate all un-insulated connections.
2. Indoors: Use general purpose, flame retardant tape or single wall heat shrink.
3. Outdoors, Dry Locations: Use flame retardant, cold- and weather- resistant tape or single wall heat shrink.
4. Below Grade and Wet or Damp Locations: Use dual wall heat shrink.

F. Cap spare conductors with UL listed end caps.

G. Cabinets, Panels, and Motor Control Centers:

1. Remove surplus wire, bridle and secure.
2. Where conductors pass through openings or over edges in sheet metal, remove burrs, chamfer edges, and install bushings and protective strips of insulating material to protect the conductors.

H. Control and Instrumentation Wiring:

1. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs.
2. Terminate with methods consistent with terminals provided, and in accordance with terminal manufacturer’s instructions.
3. Locate splices in readily accessible cabinets or junction boxes using terminal strips.
4. Cable Protection:
   a. Ensure grounds do not occur because of damage to jacket over the shield.
   b. Maintain integrity of shielding of instrumentation cables.

3.05 MEDIUM-VOLTAGE CONDUCTORS/CABLES, 15,000 VOLTS

A. Install cable and terminations in accordance with manufacturer’s instructions and to ANSI/IEEE C2.

B. Ground cable shield at each termination and splice.

C. No cable shall be pulled until the conduit system is complete from pull point to pull point.

D. Care shall be exercised while installing cable in conduits so as not to damage the conductor insulation. Ideal Industries' "Yellow-77" or "Wire Lube" or American Polywater Corporation's "Polywater J or J-WG" compound may be used in pulling nonarmored conductors and shall be used if cable is pulled by mechanical means.

E. The bending radius of any cable shall not be less than the minimum recommended by the manufacturer. Maximum pulling tension and sidewall pressure of any wire or cable shall not exceed the manufacturer's recommended values.

F. When splice kits and prefabricated terminations are used on solid dielectric 15-kV cable, the work shall be scheduled such that terminations and splices can be completed prior to the end of the work shift. If a splice or termination cannot be completed in the work shift, then the splice shall be covered with plastic and taped to exclude moisture and dirt (idle period shall not exceed 48 h). Upon continuation of the splice during the next work shift, the cable components shall be wiped clean and dry before continuing with splice completion. In all areas other than heated buildings, the wrapped incomplete splice or stress cone terminator shall be protected with silica gel for moisture absorption.

G. Temporary protection shelters (wood frame and plastic sheet or equivalent) shall be installed over work area when splicing or terminating solid dielectric cables during inclement weather or in environments where airborne contaminants are present that are detrimental to a successful splice.

3.06 TESTING - MEDIUM VOLTAGE, 15,000 VOLT CONDUCTORS/CABLE

A. General

1. Field inspection and testing will be performed under provisions of this section.

2. Inspect exposed cable sections for physical damage. Verify that cable is connected according to drawings and that shield grounding, cable support, and terminations are properly installed.

3. In setting up the test set, special safety precautions should be taken regarding grounding of the test equipment. The test set, its sphere gap (if used), its voltmeter, and the cable sheath should all be grounded to the same ground.

4. Exposed cable connections shall be attended throughout the duration of the test. The machine operator shall coordinate the overall safety effort although each organization is individually responsible for the safety of its personnel.

5. Proper insulating gloves/PPE shall be worn by test personnel making connections during all tests.

6. Test values applied shall not exceed the maximum permissible field test value of any component part included in the test.

B. Test No. 1 - Shield Continuity

A continuity test of metallic shields shall be made with an ohmmeter.

C. Test No. 2 - Insulation Resistance No. 1

1. The insulation shall be given an "Insulation Resistance Test" using a 2,500-V insulation tester (Simpson Model 405 or an approved equal). This test shall be made before the "DC High-Potential Test" (Test No. 3).

2. All 1/C insulated cables shall be tested between conductor and ground with the cable shield grounded.

3. All multiconductor insulated cables shall be tested between one of the conductors and ground with the other two conductors and cable sheath (if shielded) grounded to the same ground. Each conductor shall be successively tested in the same manner.

4. The voltage shall be applied for enough duration to fully charge the cable. Resistance readings shall be taken every 15 s during the first 3 min and at 1-min intervals thereafter. The test shall continue until three equal readings, 1 min apart, are obtained. The cable then may be considered to be fully charged.

5. Minimum acceptable resistance readings for 15-kV cables shall be 5,000 megohms for cable lengths of 1,000 ft or less.

D. Test No. 3 - High Potential

1. A "DC High-Potential Test" shall be made after all splices, potheads, and stress cones are made. This test shall be in accordance with IEEE Standard 400-1980.

2. The "DC High-Potential Test" shall be made only after the Contractor's project representative has approved an initial "Insulation Resistance Test" and before terminal equipment, such as transformers, etc., have been connected.

3. All 1/C insulated cables shall be tested between conductor and ground with the cable shield grounded.

4. All multiconductor insulated cables shall be tested between one of the conductors and ground with the other two conductors and cable sheath grounded to the same ground. Each conductor shall be successively tested in the same manner.

5. The preferred method of conducting the "DC High-Potential Test" is with the negative lead of the high-potential machine connected to the cable under test and the positive lead connected to ground. If a positive-ground machine is unavailable, the test may be made with the polarity opposite that indicated. In either case, the test report shall state which kind of machine was used.

6. New high-voltage cable installations shall be isolated from existing cable installations; existing systems contain aged PILC cable installations that cannot be tested to higher voltage levels. The "DC High-Potential Test" voltages shall be 55kV for 15kV rated cables.

7. Apply test voltage slowly, from an initial value not to exceed 15 kV, in increments of equal value (approx. 2 kV) to the maximum specified level. Allow sufficient time (1 min suggested) at each step for the leakage current to stabilize or to show unreadably low values. Record leakage current at the end of each step duration.

8. Maintain the maximum test voltage for 5 consecutive minutes. Record the leakage current values at 1-min intervals.

9. Should the leakage current values significantly increase during the soak period, the test shall be aborted. Retest shall proceed only after approval from the CONTRACTOR or DESIGNATED PROJECT REPRESENTATIVE.

10. After successful completion of the test duration or a failure is experienced, the test potential shall be removed at approximately the same rate as used during its application. Allow the residual voltage on the circuit to decay to at least 20% of the test voltage before applying manual grounds. A retest or reconnection of circuit components shall not be started until the cable has been solidly grounded for a period at least four times (20 min) the test duration.

    <u>Caution</u>: It shall be recognized that direct current charges can build up potentially dangerous levels if grounds are removed before absorption energy is dissipated.

11. For the cable to be acceptable, the steady-state leakage current values at maximum test voltage must be approximately equal and, in general, less than 25 microamperes.

12. Cables shall not be subjected to more than one "DC High-Potential Test" without the approval of the CONTRACTOR. The maximum test voltage for a second test, should it be necessary, shall be as specified by the CONTRACTOR or DESIGNATED PROJECT REPRESENTATIVE.

E. Test No. 4 - Insulation Resistance No. 2

1. The cable shall be given a second "Insulation Resistance Test" using a 2500-V insulation tester after completion of Test No. 3.

2. For the cable to be acceptable, the resistance readings must be reasonably parallel to Test No. 2 "Megger" readings.

F. Reporting Test Results

The subcontractor shall report the results of all tests with a signed and dated copy of the test reports.

END OF SECTION

SECTION 26 05 26 – GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1- GENERAL

1.01 DESCRIPTION

This specification includes ground grids, structural grounding, electrical equipment grounding, nonelectrical equipment grounding, grounding conductors, motor grounding, lighting fixture enclosure grounding, receptacle grounding, transformer neutral grounding, and communication system grounding.

The grounding of electrical equipment, grounded electrical circuits, etc., shall be in accordance with the details shown on construction drawings. In addition to the grounding specified herein or on the drawings, all ground connections required by the NEC shall be furnished and installed. Where grounding conductor sizes are omitted from the drawings, the minimum requirements of Article 250 of the NEC shall apply.

1.02 REFERENCES

A. Institute of Electrical and Electronics Engineers (IEEE): C2, National Electrical Safety Code (NESC).
B. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
C. American National Standards Institute (ANSI)/Institute of Electrical and Electronic Engineers (IEEE) Standard 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
D. IEEE 80, Guide for Safety in AC Substation Grounding.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Product data for the following:
   a. Exothermic weld connectors
   b. Mechanical connectors
   c. Compression connectors
   d. Ground Wire
   e. Ground Rods

1.04 QUALITY ASSURANCE

A. Provide the Work in accordance with ANSI.NFPA 70, National Electrical Code (NEC). Material and equipment shall be labeled or listed by a nationally recognized testing laboratory (NRTL).

Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc., shall conform to those standards and shall have an applied UL listing mark.

PART 2 - PRODUCTS

2.01 GROUND ROD

A. Material: Copper-clad

B. Diameter: Minimum 5/8 inch

C. Length: 10 ft

2.02 GROUND CONDUCTORS

A. As specified in Section 26 05 05, Conductors.

2.03 CONNECTORS

A. Exothermic Weld Type:

1. Outdoor Weld: Suitable for exposure to elements or direct burial.
2. Indoor Weld: Utilize low-smoke, low-emission process.
3. Manufacturers: Erico Products, Inc. Cadweld and Cadweld Exolon.

B. Compression Type:

1. Compress-deforming type; wrought copper extrusion material.
2. Single indentation for conductors 6 AWG and smaller.
3. Double indentation with extended barrel for conductors 4 AWG and larger.
4. Manufacturers:
    a. Burndy Corp.
    b. Thomas and Betts Co.
    c. ILSCO
    d. Or as approved

C. Mechanical Type: Split-bolt, saddle, or cone screw type; copper alloy material.

1. Manufacturers:
    a. Burndy Corp.
    b. Thomas and Betts Co.
    c. Or as approved

PART 3 - EXECUTION

3.01 GENERAL

A. Grounding shall be in compliance with NFPA 70 and IEEE C2.

B. Ground electrical service neutral at service entrance equipment to supplementary grounding electrodes.

C. Verify neutral bars in lighting and distribution panelboards are ungrounded.

D. Provide communications system grounding conductor at point of service entrance and connect to nearest grounding point.

E. Ground each separately derived system neutral to nearest effectively grounded building structural steel member or separate grounding electrode system.

F. Bond together system neutrals, service equipment enclosures, exposed noncurrent-carrying metal parts of electrical equipment, metal raceways, ground conductor in raceways and cables, receptacle ground connections, and metal piping systems, without creating ground loop.

G. The equipment -grounding conductor shall be a continuous copper wire and shall be run in the same conduit with the current carrying conductors. Aluminum ground wires are not permitted and will not be accepted. Wire installed in steel conduit may be either bare or green insulated.

H. Equipment grounding conductors shall connect to the existing ground grid at ground busses and ground inserts or to existing equipment grounding conductors. Grounding or bonding of equipment to building or equipment skid steel as a sole means of grounding will not be acceptable, and the use of conduit as the equipment grounding conductor is not permitted.

I. Connections to ground busses and connections of equipment grounding conductors shall be made with either bolted mechanical lugs or compression connectors. Before connections are made, all contact surfaces shall be clean and bright; and a compound to prevent oxidizing, such as "No-Oxide" or "Contact Aid," shall be applied to ensure good electrical contact.

J. Metal shields and/or lead sheaths of 15-kV cables shall be bonded for continuity at splices and grounded at each termination. The equipment grounding conductor shall connect to the ground grid system.

K. Shielded Power Cables: Ground shields at each splice or termination in accordance with recommendations of splice or termination manufacturer.

L. Shielded Instrumentation Cables:

1. Ground shield to ground bus at power supply for analog signal.
2. Expose shield minimum 1 inch at termination to field instrument and apply heat shrink tube.

3. Do not ground instrumentation cable shield at more than one point.

3.02 WIRE CONNECTIONS

A. Ground Conductors: Install in conduit containing power conductors and control circuits above 50 volts.

B. Nonmetallic Raceways and Flexible Tubing: Install equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.

C. Connect ground conductors to raceway grounding bushings.

D. Extend and connect ground conductors to ground bus in all equipment containing a ground bus.

E. Connect enclosure of equipment containing ground bus to that bus.

F. Bolt connections to equipment ground bus.

G. Bond grounding conductors to metallic enclosures at each end, and to intermediate metallic enclosures.

H. Junction Boxes: Furnish materials and connect to equipment grounding system with grounding clips mounted directly on box, or with 3/8-inch machine screws.

3.03 GROUND RODS

A. Install full length with conductor connection at upper end.

B. Install with connection point below finished grade, unless otherwise shown.

C. Space multiple ground rods by one rod length.

3.04 GROUNDING MATS

A. Install neutral grounding equipment according to equipment manufacturer's instructions.

B. Install ground mat 18 inches below grade (unless noted otherwise on drawings) with riser connectors for equipment connections ring.

C. Make underground connections by thermic process where possible, or with cast-copper compression connectors in areas where thermic welds are not acceptable.

3.05 CONNECTIONS

A. General:

1. Abovegrade Connections: Install exothermic weld, mechanical, or compression-type connectors.
2. Belowgrade Connections: Install exothermic weld.
3. Remove paint, dirt, or other surface coverings at connection points to allow good metal-to-metal contact.

B. Exothermic Weld Type:

1. Wire brush or file contact point to bare metal surface.
2. Use welding cartridges and molds in accordance with manufacturer's recommendations.
3. Avoid using badly worn molds.
4. Mold to be completely filled with metal when making welds.
5. After completed welds have cooled, brush slag from weld area and thoroughly clean joint.

C. Compression Type:

1. Install in accordance with connector manufacturer's recommendations.
2. Install connectors of proper size for grounding conductors and ground rods specified.
3. Install using connector manufacturer's compression tool having proper sized dies.

D. Mechanical Type:

1. Apply homogeneous blend of colloidal copper and rust and corrosion inhibitor before making connection.
2. Install in accordance with connector manufacturer's recommendations.
3. Do not conceal mechanical connections.

3.06 METAL STRUCTURE GROUNDING

A. Ground metal sheathing and exposed metal vertical structural elements to grounding system.

B. Bond electrical equipment supported by metal platforms to the platforms.

C. Provide electrical contact between metal frames and railings supporting pushbutton stations, receptacles, and instrument cabinets, and raceways carrying circuits to these devices.

3.07 TRANSFORMER GROUNDING

A. Bond neutrals of transformers within buildings to system ground network, and to any additional indicated grounding electrodes.

B. Bond neutrals of pad-mounted transformers to locally driven ground rod and connect to system ground network.

3.08 SURGE PROTECTION EQUIPMENT GROUNDING

A. Connect surge arrestor ground terminals to equipment ground bus or system ground network.

3.09 FIELD TESTING

A. Test Individual Ground Rods: Each ground rod shall be tested for resistance to earth by a Biddle null balance "Earth Tester," using the "Three-Point-Method" described in ANSI/IEEE Standard 81 using two auxiliary rods.

B. Individual ground rod resistance to earth shall be 15 ohms or less. If the resistance is found to be higher than 15 ohms, additional ground rods shall be driven and connected in multiple, with the rod under test until 15 ohms are obtained. Spacing of rods shall be a minimum of 10 ft.

C. Test equipment ground conductor terminations and busses in electrical equipment to ensure low resistance connections. Maximum permissible resistance shall be 0.1 ohm for equipment bus to ground grid, and 0.01 ohm for equipment ground bus to equipment enclosures.

END OF SECTION

SECTION 26 05 53 – IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. This work includes permanently identifying electrical equipment, conduit, and wiring installed under this contract.

1.02 RELATED SECTIONS

A. Section 26 05 00 Common Work Results for Electrical.

1.03 SUBMITTALS

A. Submit a cut sheet or sample of each type of electrical identification proposed for use.

PART 2 PRODUCTS

2.01 MATERIALS

A. General:

1. Use weather-resistant nameplates/tags on outdoor equipment.
2. Identification of equipment is to include: Maximum voltage, equipment designation, source of supply, and equipment supplied.

B. Disconnect switch identification.

1. Identify and tag all disconnect switches as to the load served, consistent with the drawings. Use weather-resistant nameplates on outdoor equipment. Disconnect switch tags shall be engraved aluminum or laminated plastic, black letters on white background. Lettering shall be 3/8 inch minimum.
2. Attach tags to disconnect switches with screws, rivets, or a permanent adhesive suitable for wet locations. Thoroughly clean/degrease the disconnect switch with rubbing alcohol immediately before applying the tag.

C. Conductor identification.

1. Identify and tag power and control conductors (10 AWG or smaller) and control and communication cables at each termination, consistent with associated drawings. Tags shall be legible, permanent, self-adhesive wrap-around tags or sleeves specifically intended for industrial wire marking use. Tags shall be self-laminating, unless an abrasion-resistant thermal transfer printing process is used. Tags shall be Brady, Panduit,

or equal. All circuit identification tags shall be readily accessible for inspection at termination points.

2. Identify all three-phase power feeder conductors by phase designations (e.g., 0/A, 0/B, 0/C).

D. Conduit identification.

1. Identify all scheduled conduits within 6 inches of where they enter each enclosure, underground vault, and pull box with their conduit number as indicated on the conduit schedule. Use a paint pen marker to write neatly the conduit number on the conduit in a location that will remain visible after project completion. Use Speedball Painters paint pen markers or equal. Ordinary ink-based permanent markers are not acceptable. Machine-printed wrap-around permanent adhesive labels are acceptable as an alternative.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install all identification in a workman-like fashion. Insure that all identification is consistent with the drawings.

END OF SECTION

SECTION 26 20 00–LOW-VOLTAGE ELECTRICAL DISTRIBUTION

PART 1 GENERAL

1.1 SUMMARY

A. Provide low-voltage electrical distribution.

1.2 SUBMITTALS

A. Product Data: Submit manufacturer's product data and installation instructions for each material and product used. List project-specific information, including incoming service characteristics, connection types, transformers, and distribution system characteristics if available.

B. Shop Drawings: Submit shop drawings indicating material characteristics, details of construction, connections, and relationship with adjacent construction.

C. Operation and Maintenance Data: Submit manufacturer's operation and maintenance data, including operating instructions, list of spare parts and maintenance schedule.

1.3 QUALITY ASSURANCE

A. Comply with governing codes and regulations. Provide products of acceptable manufacturers, which have been in satisfactory use in similar service for three years. Use experienced installers. Deliver, handle, and store materials in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 MATERIALS

A. Low-Voltage Electrical Distribution:
   1. Manufacturers: Subject to compliance with requirements
   2. Sustainable Design: Utility efficient equipment and fixtures
   3. Sustainable Design: Commissioning
   4. Low-Voltage Transformers:
      a. Dry Type Transformers: NEMA ST 20, copper windings.
   5. Low Voltage Switchgear Assemblies: IEEE C37.20.1 and UL 1558.
   6. Switchboards:
      a. Buses and Connections: Three-phase, four-wire type.
      b. Overcurrent Protective Devices (OCPDs): Ratings, settings suitable for use.
      c. Circuit Control and Protective Devices: Transfer switches, surge arrestors.
      d. Instrument Transformers: NEMA EI 21.1, IEEE C57.13.
      e. Ratings: System voltage, main bus amperage, short-circuit-current rating.

f. Switchboard Type: Front-connected, front-accessible, panel-mounted branches.
g. Switchboard Type: Front and side accessible sections.
h. Switchboard Type: Front and rear accessible sections.
i. Enclosure: NEMA 1, indoor.
j. Enclosure: NEMA 3R, rainproof.

7. Panelboards:
   a. Panelboards: NEMA PB 1, UL 50, 61, IEEE C62.1 surge arresters.
   b. Panelboard Type: Load-center-type panelboards.
8. Wiring Devices and Components:
   a. Receptacles: UL 498 and NEMA WD 1.
   b. Industrial Receptacles: UL 498; UL 1010 at hazardous locations.
   c. Ground-Fault Interrupter Receptacles: Feed-thru type ground-fault circuit type.
9. Grounding:
   a. Grounding Equipment: UL 467; copper conductors; wire and cable conductors.
   b. Grounding Electrodes: Copper-clad steel ground rods; copper plate electrodes.
10. Fuses:
   a. Cartridge Fuses: ANSI/IEEE FU 1, nonrenewable cartridge type.
   b. Spare Fuse Cabinet: Wall-mounted steel unit.
11. Overcurrent Protective Devices:
   a. Overcurrent Protective Devices: Integral to panelboards and switchboards.
   b. Cartridge Fuses: NEMA FU 1, class suitable for use.
   c. Fusible Switches: UL 98, NEMA KS 1.
   d. Fused Power Circuit Devices: UL 977.
   e. Molded Case Circuit Breakers:UL 489, NEMA AB 1.
   f. Insulated Case Circuit Breakers: UL 489, NEMA AB 1.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install materials and systems in accordance with manufacturer's instructions and approved submittals. Install materials in proper relation with adjacent construction and with uniform appearance for exposed work. Coordinate with work of other sections. Provide proper clearances for servicing.

B. Maintain indicated fire ratings of walls, partitions, ceilings and floors at penetrations. Seal with firestopping to maintain fire rating.

C. Test all systems for proper operation. Label circuits in electrical panels. Restore damaged finishes. Clean and protect work from damage.

D. Instruct Owner's personnel in proper operation of systems.

END OF SECTION

SECTION 26 22 98 – OVERHEAD POWER DISTRIBUTION

PART 1 - GENERAL

1.01 SECTION INCLUDES:

A. Poles

B. Crossarms

C. Insulators

D. Arresters

E. Cutouts

F. Pole hardware

G. Overhead line conductors

H. Anchors

I. Guy guards

J. Grounding

1.02 REFERENCES

A. ANSI C2, National Electrical Safety Code

B. ANSI C29.xx, Electrical Power Insulators

C. ANSI C37.42, Switchgear - Distribution Cutouts and Fuse Links - Specifications

D. ANSI C57.x, Power Transformers

E. ANSI C135.1, Galvanized Steel Bolts and Nuts for Overhead Line Construction

F. ANSI C135.2, Threaded Zinc-Coated Ferrous Strand-Eye Anchor Rods and Nuts for Overhead Line Construction

G. ANSI C135.4, Zinc-Coated Ferrous Eyebolts and Nuts for Overhead Line Construction

H. ANSI C135.5, Zinc-Coated Ferrous Eyenuts and Eyelets for Overhead Line Construction

I. ANSI C135.17, Galvanized Ferrous Bolt-Type Insulator Pins with Lead Threads for Overhead Line Construction

J. ANSI C135.22, Zinc-Coated Ferrous Pole-Top Insulator Pins with Lead Threads for Overhead Line Construction

K. ANSI C135.30, Zinc-Coated Ferrous Ground Rods for Overhead or Underground Line Construction

L. ANSI C135.31, Zinc-Coated Ferrous Single and Double Upset Spool Insulator Bolts for Overhead Line Construction

M. ANSI O5.1, Wood Poles - Specifications and Dimensions

N. ASTM A475, Standard Specification for Zinc-Coated Steel Wire Strand

O. ASTM A675 and ASTM A675, Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties

P. ASTM B1, Standard Specification for Hard-Drawn Copper Wire

Q. ASTM B2, Standard Specification for Medium-Hard-Drawn Copper Wire

R. ASTM B3, Standard Specification for Soft or Annealed Copper Wire

S. ASTM B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

T. ASTM B228, Standard Specification for Concentric-Lay-Stranded Copper-Clad Steel Conductors

U. ASTM B232, Standard Specification for Concentric-Lay-Stranded Aluminum Conductors, Coated-Steel Reinforced (ACSR)

V. AWPA C2, Standard for the Preservative Treatment by Pressure Processes - All Timber Products

W. AWPA C4, Standard for the Preservative Treatment of Poles by the Pressure Process

X. AWPA C25, Standard for the Preservative Treatment of Crossarms by the Pressure Process

Y. NEMA LA1, Surge Arresters

Z. UL 96, Standard for Safety Lightning Protection Components

1.03 SUBMITTALS

A. Submit the following product data for information.

1. Insulators/Terminations

2. Line conductors

3. Arresters/cut-outs/current limiters/fuses

4. Poles/crossarms/pole hardware

5. Guy wires

6. Anchors

B. Submit as-built drawings showing exact locations of poles, guys, and anchors, and required horizontal and vertical clearances.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver overhead poleline hardware on-site and inspect for damage.

B. Protect poles from damage and decay by stacking to provide free circulation of air. Maintain 1-ft-min spacing between bottom pole and ground or ground vegetation. Do not store poles above decayed or decaying wood.

C. Stack poles stored for more than 2 weeks on treated or decay-resistant skids arranged to support poles without noticeable pole distortion.

D. Handle treated poles with tools which will not produce an indentation greater than 1 inch deep. Do not drag treated poles along ground. Do not apply tools to that section of treated poles between 1 ft above and 2 ft below ground line.

PART 2 - PRODUCTS

2.01 POLES AND CROSSARMS

A. Crossarms and Timbers: Straight-grained Douglas fir free of twists to within 0.1 inch/ft of length, with bends and twists in only one direction.

B. Preservative: CCA preservative in accordance with AWPA C25.

C. Crossarm Dimensions: As shown on drawings.

D. Wood Poles: ANSI O5.1; treated Southern yellow pine, length and class as indicated.

E. Select poles for straightness and minimum sweeps and short crooks.

F. Preservative: CCA Type C according to AWPA C1 and AWPA C4.

G. Preservative shall be applied by manufacturer to AWPA C1 and AWPA C4 with minimum net retention of 0.6 lb/ft^3. Obtain complete sapwood penetration.

2.02 POLE HARDWARE

A. Miscellaneous Pole Hardware: Hot-dipped galvanized after fabrication.

B. Crossarm Braces: ASTM A675; structural steel zinc coated.

C. Angle Braces: Drop-formed in one piece from 1 3/4-in. X 1 3/4-in. angle.

D. Flat Braces: 1/4 in. X 1 1/4 in. X 28 inch

E. Eye Bolts and Nuts: ANSI C135.4

F. Anchor Rods and Nuts: ANSI C135.2

G. Bolts and Nuts: ANSI C135.1

H. Eyenuts and Eyelets: ANSI C135.5

I. Ground Rods: ANSI C135.30

J. Butt Plate: Copper

K. Bolt-type Insulator Pins: ANSI C135.17

L. Pole-top Insulator Pins: ANSI C135.22

M. Hot-line Clamps: Screw type with concealed threads. Fill thread chamber with corrosion-resistant compound.

2.03 INSULATORS

A. Insulators: 15kV rated ANSI 55-5 class insulators, radio-freed with minimum 80kV dry flashover rating and 45kV wet flashover rating on 60Hz system. Insulators shall be manufactured to ANSI C29.2, 4, 7, & 9 for 15kV Class insulators.

2.04 GROUNDING

A. Ground Rods: Copperweld type, 3/4 inch diam, minimum length 15 ft

B. Ground Wire: Bare, soft-drawn copper, No. 6 AWG minimum size

C. Ground Wire Protectors: PVC molding, 8 ft long

2.05 ARRESTERS AND CUTOUTS

A. Surge Arresters: NEMA LA1; metal oxide type, arranged for crossarm mounting, and 15kV

B. Fused Cutouts: ANSI C37.42; fused cutouts frame rated 300 A at 14.4 kV ungrounded

C. Fuses: Type K, rated as indicated

2.06 LINE CONDUCTORS

A. Medium-Voltage Overhead Line Conductors: Bare ASCR, size as noted on the drawings

B. Aluminum Conductor Steel Reinforced Line: ASTM B232

C. Overhead Ground Conductor: ASTM B232; ASCR

D. Guy Strand: ASTM A475, high-strength grade, Class A or B; galvanized, seven-strand steel cable

E. Secondary Conductors: Aluminum, triplex cable with 600-V cross-linked polyethylene insulation for phase conductors. Use bare ACSR messenger for neutral.

2.07 ANCHORS AND ANCHOR RODS

A. Anchors: 8-inch screw type

B. Anchor Rods: Twin-eye threaded, 3/4 inch diam, 7 ft long, hot-dip galvanized

C. Guy Guards: Yellow-colored plastic, 7 ft long, shatter-resistant at subzero temperatures

D. Guy Attachments: Solid bail, strandvise, or three-bolt clamp type

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify site is ready to receive work.

B. Verify field measurements are as shown.

C. Verify required utilities are available in proper location and ready for use.

D. Obtain excavation permit prior to commencing dirt work for pole installation.

3.01 PREPARATION

A. Cut gains on face of pole, with gained surfaces in parallel planes.

B. Shorten poles when required by cutting from top end. Apply hot preservative to shortened end of pole.

C. Dig setting holes large enough to permit use of tampers to full depth.

D. Depth of pole settings: ANSI 05.1.

E. Depths are minimum for normal firm ground and are measured from lower side of pole.

3.02 INSTALLATION

A. Poles

1. Set poles in straight line where possible. Place curved poles with curvature in line with lead pole. Maintain an even grade.

2. Backfill; place earth in maximum 6-inch layers and pack to 45% density.

3. Rake poles located at corners, angles, and dead ends so that poles are vertical after line installation.

4. Do not install poles along the edge of cuts and embankments or where soil may be washed out.

5. Identify each pole as indicated using aluminum marker stamped with characters 2 1/2-inch-high minimum. Locate to provide maximum visibility and fasten with aluminum nails.

B. Anchors and Guys

1. Place anchors in line with strain, with rod in line and pointing at guy attachment on pole.

2. Install rod eye 6 inch to 9 inch abovegrade after strain is applied.

C. Crossarms

1. Set crossarms at right angles to line for straight runs and to bisect angle of turns in line direction.

2. Provide two braces for each crossarm.

D. Conductors

1. Complete guy installation, dead end to dead end before stringing and sagging is begun.

2. Install conductors to ANSI C2. Equalize sags before tying to pin insulators.

3. Install static line. Equalize sags before attaching to pole.

3.03 PROTECTION

A. Plug unused holes in poles using treated wood dowel pins. Treat field-cut gains and field-bored holes with preservative.

END OF SECTION

SECTION 26 22 99–MEDIUM VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.01 SUMMARY

A. This work includes installation and testing of one (1) medium voltage (15kV class) transformer.

1.02 SECTION INCLUDES

A. Transformers

1.03 RELATED SECTIONS

A. Section 26 05 00 Common Work Results for Electrical

B. Section 26 05 53 Identification for Electrical Systems

PART 2 PRODUCTS

2.01 MATERIALS

A. One (1) medium voltage transformers shall be provided by the Contractor for use through the project duration. Installation and testing shall be provided by the Subcontractor. The transformers shall consist of liquid-filled, 3-phase pad-mounted, sized for 2,500 kVA and rated for outdoor use.

B. Provide materials and construction of a grounded concrete pad in outside environment with dimensions minimum of 2 ft beyond footprint of transformer base, and as noted in contract drawings.

C. Provide materials and conductors to connect to a primary 14.4 kVac, 3-phase delta system, and a secondary 480 Vac, 3-phase, wye, distribution panel with a secondary main circuit breaker.

D. Provide materials and installation of primary and secondary terminations in compliance with ANSI/IEEE C57. Primary connections shall be radial-feed, dead-front system with dual (A & B) bushing terminals for each phase. Primary shall include internal gang-operated switching. Primary protection shall include Bay-O-Net type expulsion fuses and oil-submersible protector (OSP) partial-range current limiting fuses. These fuses are to be in series for two-part fault protection.

E. All transformer anchors shall be installed with corrosion resistant hardware in accordance with manufacturer's instructions.

PART 3 EXECUTION

3.01 INSTALLATION

A. Ground and bond transformers with grounding system wire, and pad grounding system in accordance with manufacturer's instructions.

B. Install primary and secondary conductors in accordance with manufacturer's instructions and as noted on contract drawings.

C. Set tap changer settings in accordance with system voltage.

D. Coordinate all start-up and testing activities with the Contractor's designated technical support personnel.

E. After installation is complete, the transformer shall be tested for the following:

- Visual and mechanical inspections
- Fluid levels checks
- Transformer insulation resistance checks of both high-voltage and low-voltage
- High-potential voltage test of primary impacts
- Auxiliary devices check for proper operation, including dial type thermometer, oil level gauge, and pressure/vacuum gauge

F. Verify proper voltage levels, phasing, and frequency output for system connection.

3.02 FIELD QUALITY CONTROL

A. Test all transformers for proper connection and operation. Provide test reports and notify Contractor of any deficiencies found. Replace any auxiliary units that do not function properly.

END OF SECTION

SECTION 26 24 16 – PANELBOARDS

PART 1 - GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Institute of Electrical and Electronics Engineers (IEEE):
   a. C62.1, Surge Arresters for Alternating Current Power Circuits.
   b. C62.11, Standards for Metal-Oxide Surge Arrestors for AC Power Circuits.
2. National Electrical Contractor's Association (NECA): 407, Recommended Practice for Installing and Maintaining Panelboards.
3. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum)
   b. 289, Application Guide for Ground Fault Circuit Interrupters
   c. AB 1, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
   d. KS 1, Enclosed Switches
   e. LA 1, Surge Arrestors
   f. PB 1, Panelboards
   g. PB 1.1, General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC)
5. Underwriters Laboratories Inc. (UL):
   a. 67, Standard for Panelboards
   b. 98, Standard for Enclosed and Dead-Front Switches
   c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors
   d. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   e. 508, Standard for Industrial Control Equipment
   f. 870, Wireways, Auxiliary Gutters and Associated Fittings
   g. 943, Standard for Ground-Fault Circuit-Interrupters

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer's data sheets for each type of panelboard, protective device, accessory item, and component.
2. Manufacturer's shop drawings including dimensioned plan, section, and elevation for each panelboard type, enclosure, and general arrangement.
3. Tabulation of features for each panelboard to include the following:
   a. Protective devices with factory settings
   b. Provisions for future protective devices
   c. Space for future protective devices
   d. Voltage, frequency, and phase ratings
   e. Enclosure type
   f. Bus and terminal bar configurations and current ratings

g. Provisions for circuit terminations with wire range
h. Short circuit current rating of assembled panelboard at system voltage
i. Features, characteristics, ratings, and factory settings of auxiliary components

B. Informational Submittals:

1. Manufacturer's recommended installation instructions.

1.03 QUALITY ASSURANCE

A. Listing and Labeling: Provide products specified in this Section that are listed and labeled as defined in NEC Article 100.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Square D Company
2. Eaton/Cutler-Hammer
3. General Electric Co.
4. Or as approved

B. Panelboards shall be of the same manufacturer as equipment furnished under Switchboards and Low-Voltage Switchgear.

2.02 GENERAL

A. Provide low voltage panelboards for application at 600V or less in accordance with this Section including panelboards installed in other equipment specified in Section, Low-Voltage Motor Control, Switchboards, Low-Voltage Switchgear**.**

B. Provide equipment in accordance with NEMA PB 1, NFPA 70, and UL 67.

C. Wire Terminations:

1. Panelboard assemblies, including protective devices, shall be suitable for use with 75 degrees C or greater wire insulation systems at NEC 75 degrees C conductor ampacity.
2. In accordance with UL 486E.

D. Load Current Ratings:

1. Unless otherwise indicated, load current ratings for panelboard assemblies, including bus and circuit breakers, are noncontinuous as defined by NEC. Continuous ratings shall be 80 percent of noncontinuous rating.
2. Where indicated "continuous," "100 percent," etc., selected components and protective devices shall be rated for continuous load current at value shown.

E. Short Circuit Current Rating (SCCR): Integrated equipment short circuit rating for each panelboard assembly shall be no less than the fault current available as shown at point of application in distribution system.

F. Overcurrent Protective Devices:

1. In accordance with NEMA AB 1, NEMA KS 1, UL 98, and UL 489.
2. Protective devices shall be adapted to panelboard installation.
   a. Capable of device replacement without disturbing adjacent devices and without removing main bus.
   b. Spaces: Cover openings with easily removable cover.

G. Circuit Breakers:

1. General: Thermal-magnetic unless otherwise indicated, quick-make, quick-break, molded case, of indicating type showing ON/OFF and TRIPPED positions of operating handle.
2. Noninterchangeable: In accordance with NEC.
3. Bus Connection: Bolt-on circuit breakers in all panelboards: Bolt-on circuit breakers in 480Y/277-volt, and plug-in circuit breakers in 208Y/120 and 240/120-volt branch circuit panelboards. In power distribution panelboards, 225-ampere frame size and greater may be plug-in type where individual positive locking device requires mechanical release for removal.
4. Trip Mechanism:
   a. Individual permanent thermal and magnetic trip elements in each pole.
   b. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
   c. Two and three pole, common trip.
   d. Automatically opens all poles when overcurrent occurs on one pole.
   e. Test button on cover.
   f. Calibrated for 40 degrees C ambient, unless shown otherwise.
5. Unacceptable Substitution:
   a. Do not substitute single-pole circuit breakers with handle ties for multi-pole breakers.
   b. Do not use tandem or dual circuit breakers in normal single-pole spaces.
6. Ground Fault Circuit Interrupter (GFCI): Where indicated, equip breaker as specified above with ground fault sensor and rated to trip on 5-mA ground fault within 0.025 second (UL 943, Class A sensitivity, for protection of personnel).
   a. Ground fault sensor shall be rated same as circuit breaker.
   b. Push-to-test button.
   c. Reset button.
7. Equipment Ground Fault Interrupter (EGFI): Where indicated, equip breaker specified above with ground fault sensor and rated to trip on 30-mA ground fault (UL listed for equipment ground fault protection).

H. Enclosures:

1. Provide as specified in Section**,** Basic Electrical Materials and Methods .
2. Material: Type 1, Type 3R, and Type 3S shall be code-gauge, hot-dip galvanized sheet steel with reinforced steel frame.
3. Finish: Rust inhibitor prime followed by manufacturer’s standard gray baked enamel or lacquer.

I. Bus:

1. Material Copper full sized throughout length. Provide bolted connections with Belleville washers where aluminum bus is provided.
2. Provide for mounting of future protective devices along full length of bus regardless of number of units and spaces shown. Machine, drill, and tap as required for current and future positions.

J. Feeder Lugs: Main, feed-through, and neutral shall be replaceable, bolted mechanical or crimp compression type.

K. Equipment Ground Terminal Bus: Copper with suitably sized provisions for termination of ground conductors, and bonded to box.

1. Provide individual mechanical termination points no less than the quantity of breaker pole positions.
2. Provide individual termination points for all other grounding conductors such as feeder, grounding electrode, etc.
3. Termination points shall be bolted crimp compression lugs for conductors 6 AWG and larger**.**

L. Neutral Terminal Bus: Copper with suitably sized provisions for termination of neutral conductors, and isolated from box.

1. Provide individual mechanical termination points no less than the quantity of breaker pole positions.
2. Provide individual termination points for all other neutral conductors.
3. Termination points shall be bolted crimp compression lugs for conductors 6 AWG and larger.

M. Provision for Future Devices: Equip with mounting brackets, bus connections, and necessary appurtenances for future protective device ampere ratings indicated.

2.03 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARDS

A. Multi-Section Panelboards: Where more than 42 poles are required or more than one section is otherwise indicated, provide multiple panelboards with separate fronts.

1. Panelboard sections shall be individually installed and field interconnected to form a single electrical unit.
2. Unless otherwise indicated, provide feed-through lugs on each section but last.
3. Surface-mount panels shall be individually mounted and may be different sizes.
4. Recessed-mount panels shall be individually mounted and the same size tub and flush cover.
5. Surface-mount multisection panelboards may be comprised of sections of unequal heights.
6. Provide feed-through and main lugs in individual sections as required for field assembly of a complete multi-section panelboard.
7. Provide neutral and ground terminal bars in each section.

2.04 POWER DISTRIBUTION PANELBOARDS

A. Branch Protective Devices:

1. Locking: Furnish devices with provisions for handle padlocking.
2. Load Connections: Wire lugs shall be mechanical or crimp compression type**,** removable/replaceable, and suitable for 75 degrees C rated conductors without derating switch or conductor ampacity.
3. Provide a nameplate for each circuit, blanks for spares.

B. Fused Switch:

1. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.
2. UL 98 listed for use and location of installation.
3. NEMA KS 1.
4. Fuse Provisions:
   a. 30-amp to 600-amp rated shall incorporate rejection feature to reject all fuses except Class R.
   b. 601-amp rated and greater shall accept Class L fuses, unless otherwise shown.
5. Interlock: Fuse cover and switch shall be interlocked to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.
6. Fuse: As specified in Basic Electrical Material and Methods.

PART 3 - EXECUTION

3.01 GENERAL

A. Install in accordance with NECA 407, NEMA PB 1.1 and manufacturers' written installation instructions.

B. Install securely, plumb, in-line and square with walls.

C. Install top of cabinet trim78 inches above floor, unless otherwise shown. Install cabinet so tops of protective device operating handles are no more than 78 inches above the floor.

D. Ground Fault Protection: Install panelboard ground fault circuit interrupter devices in accordance with installation guidelines of NEMA 289.

E. Install filler plates in unused spaces.

F. Wiring in Panel Gutters: Train conductors neatly in groups; bundle, and wrap with nylon wire ties.

3.02 BRANCH CIRCUIT PANELBOARD

A. Mount flush panels uniformly flush with wall finish.

B. Provide typewritten circuit directory for each panelboard.

C. In addition to conduit or nipples otherwise required for feeder and branch circuit wiring between multi-section panelboard sections, provide nipples for branch circuits two trade sizes larger than required for installed branch circuit wires or an empty 2-inch nipple, or a 1-1/4-inch trade size conduit if tubs are more than 24 inches apart.

3.03 POWER DISTRIBUTION PANELBOARD

A. Provide engraved identification for each protective device.

3.04 SUPPLEMENTS

A. The supplements listed below are a part of this specification.

1. Panelboard Schedules

END OF SECTION

SECTION 26 56 00 – EXTERIOR LIGHTING

PART 1 GENERAL

1.1 SUMMARY

A. Provide exterior lighting.

1.2 SUBMITTALS

A. Product Data: Submit manufacturer's product data and installation instructions for each material and product used.

B. Shop Drawings: Submit shop drawings indicating material characteristics, details of construction, connections, and relationship with adjacent construction.

C. Operation and Maintenance Data: Submit manufacturer's operation and maintenance data, including operating instructions, list of spare parts, and maintenance schedule.

1.3 QUALITY ASSURANCE

A. Comply with governing codes and regulations. Provide products of acceptable manufacturers that have been in satisfactory use in similar service for three years. Use experienced installers. Deliver, handle, and store materials in accordance with manufacturer's instructions.

B. Compliance: NFPA 70 "National Electrical Code."

PART 2 PRODUCTS

2.1 MATERIALS

A. Exterior Lighting:
   1. Manufacturers: Subject to compliance with requirements.
   2. Application: Industrial floodlighting
   3. Sustainable Design: Utility efficient equipment and fixtures
   4. Sustainable Design: Commissioning
   5. Exterior Lighting Components:
      a. Fluorescent Fixtures: UL 1570; ballasts, UL 935, energy-saving
      b. High Intensity Discharge (HID) Fixtures: UL 1572; ballasts, UL 1029
      c. Incandescent Fixtures: UL 1571
      d. LED Fixtures: UL 844
      e. LED Light Source: UL 8750
      f. Lamps: ANSI Standards, C78 series
   6. Fixture Support Poles, Mast Arms and Brackets:
      a. Steel tubing
      b. Aluminum

c. Fiberglass
d. Laminated wood
e. Pressure-treated wood

PART 3 EXECUTION

3.1 INSTALLATION

A. Install materials and systems in accordance with manufacturer's instructions and approved submittals. Install materials in proper relation with adjacent construction and with uniform appearance for exposed work. Coordinate with work of other sections. Comply with applicable regulations and code requirements. Provide proper clearances for servicing.

B. Clearly label and tag all components.

C. Test and balance all systems for proper operation.

D. Restore damaged finishes. Clean and protect work from damage.

E. Instruct Owner’s personnel in proper operation of systems.

END OF SECTION

SECTION 26 99 98 – COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 – GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section.

1. ASTM International (ASTM):
    a. D877, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
    b. D923, Standard Practice for Sampling Electrical Insulating Liquids.
    c. D924, Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
    d. D971, Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
    e. D974, Standard Test Method for Acid and Base Number by Color-Indicator Titration.
    f. D1298, Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
    g. D1500, Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).
    h. D1524, Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field.
    i. D1533, Standard Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration.
    j. D1816, Standard Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Using VDE Electrodes.
2. Institute of Electrical and Electronics Engineers (IEEE):
    a. 43, Recommended Practice for Testing Insulating Resistance of Rotating Machinery.
    b. 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminators Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5kV through 500kV.
    c. 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
    d. 95, Recommended Practice for Insulation Testing of AC Electric Machinery (2300V and Above) with High Direct Voltage.
    e. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
    f. 400, Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems.
    g. 450, Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
    h. C2, National Electrical Safety Code.

i. C37.20.1, Standard for Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear.
j. C37.20.2, Standard for Metal-Clad Switchgear.
k. C37.20.3, Standard for Metal-Enclosed Interrupter Switchgear.
l. C37.23, Standard for Metal-Enclosed Bus.
m. C62.33, Standard Test Specifications for Varistor Surge-Protective Devices.

3. Insulated Cable Engineers Association (ICEA):
   a. S-93-639, 5-46 kV Shielded Power Cables for Use in the Transmission and Distribution of Electric Energy.
   b. S-94-649, Concentric Neutral Cables Rated 5 through 46 kV.
   c. S-97-682, Standard for Utility Shielded Power Cables Rated 5 through 46 kV.
4. National Electrical Manufacturers Association (NEMA):
   a. AB 4, Guidelines for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications.
   b. PB 2, Deadfront Distribution Switchboards.
   c. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.
5. InterNational Electrical Testing Association (NETA): ATS, Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
6. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC)
   b. 70B, Recommended Practice for Electrical Equipment Maintenance
   c. 70E, Standard for Electrical Safety in the Workplace
   d. 101, Life Safety Code
7. National Institute for Certification in Engineering Technologies (NICET)
8. Occupational Safety and Health Administration (OSHA): *CFR* 29, Part 1910, Occupational Safety and Health Standards

1.02 SUBMITTALS

B. Informational Submittals:

1. Submit test or inspection reports and certificates for each electrical item tested within 30 days after completion of test.
2. Operation and Maintenance Data:
   a. After test or inspection reports and certificates have been reviewed and accepted by the Contractor, provide a copy of each with Operation and Maintenance Manual.

1.03 QUALITY ASSURANCE

C. Test equipment shall have an operating accuracy equal to or greater than requirements established by NETA ATS.

D. Test instrument calibration shall be in accordance with NETA ATS.

1.04 SEQUENCING AND SCHEDULING

E. Perform inspection and electrical tests after equipment has been installed.

F. Perform tests with apparatus de-energized whenever feasible.

G. Inspection and electrical tests on energized equipment shall be:

1. Scheduled with Contractor prior to de-energization.
2. Minimized to avoid extended period of interruption.

H. Notify Contractor 24 hours prior to performing tests on energized electrical equipment.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01 GENERAL

A. Tests and inspections shall establish:

1. Electrical equipment is operational within industry and manufacturer's tolerances and standards.
2. Installation operates properly.
3. Equipment is suitable for energization.
4. Installation conforms to requirements of Contract Documents and NFPA 70, NFPA 70E, NFPA 101, and IEEE C2.

B. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer's recommendations.

C. Set, test, and calibrate: protective relays, circuit breakers, fuses, and other applicable devices in accordance with values as specified.

D. Adjust mechanisms and moving parts of equipment for free mechanical movement.

E. Adjust and set electromechanical electronic relays and sensors to correspond to operating conditions, or as recommended by manufacturer.

F. Verify nameplate data for conformance to Contract Documents and approved Submittals.

G. Realign equipment not properly aligned and correct unlevel status.

H. Properly anchor electrical equipment found to be inadequately anchored.

I. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench/screw driver to manufacturer's recommendations, or as otherwise specified in NETA ATS.

J. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

K. Provide proper lubrication of applicable moving parts.

L. Inform Engineer of working clearances not in accordance with NFPA 70.

M. Investigate and repair or replace:

1. Electrical items that fail tests.
2. Active components not operating in accordance with manufacturer's instructions.
3. Damaged electrical equipment.

N. Electrical Enclosures:

1. Remove foreign material and moisture from enclosure interior.
2. Vacuum and wipe clean enclosure interior.
3. Remove corrosion found on metal surfaces.
4. Repair or replace, as determined by Engineer door and panel sections having dented surfaces.
5. Repair or replace, as determined by Engineer poor fitting doors and panel sections.
6. Repair or replace improperly operating latching, locking, or interlocking devices.
7. Replace missing or damaged hardware.
8. Finish:
   a. Provide matching paint and touch up scratches and mars.
   b. If required due to extensive damage, as determined by Engineer refinish entire assembly.

O. Replace fuses and circuit breakers that do not conform to size and type required by the Contract Documents or approved Submittals.

3.02 CHECKOUT AND STARTUP

A. Voltage Field Test:

1. Check voltage at point of termination of supply system to Project when installation is essentially complete and is in operation.
2. Check voltage amplitude and balance between phases for loaded and unloaded conditions.
3. Unbalance Corrections:
   a. Notify of condition if balance (as defined by NEMA) exceeds 1 percent, or if voltage varies from loaded to unloaded condition more than plus or minus 4 percent of nominal.

B. Equipment Line Current Tests:

1. Check line current in each phase for each piece of equipment.
2. If phase current for a piece of equipment is above rated nameplate current, notify condition and potential cause of problem.

3.03 SWITCHGEAR AND SWITCHBOARD ASSEMBLIES

A. Visual and Mechanical Inspection:

1. Insulator damage and contaminated surfaces.
2. Proper barrier and shutter installation and operation.
3. Proper operation of indicating devices.
4. Improper blockage of air-cooling passages.
5. Integrity and contamination of bus insulation system.
6. Check door and any device interlocking system.
7. Check nameplates for proper identification of:
    a. Equipment title and tag number with latest one-line diagram
    b. Pushbutton
    c. Control switch
    d. Pilot light
    e. Circuit breaker
    f. Indicating meter
8. Verify fuse and circuit breaker ratings, sizes, and types conform to those specified.
9. Check bus and cable connections for high resistance by low resistance ohmmeter.
10. Check operation and sequencing of electrical and mechanical interlock systems by:
    a. Closure attempt for locked open devices.
    b. Opening attempt for locked closed devices.
    c. Key exchange to operate devices in OFF-NORMAL positions.
11. Verify performance of each control device and feature.
12. Control Wiring:
    a. Compare wiring to local and remote control and protective devices with elementary diagrams.
    b. Proper conductor lacing and bundling.
    c. Proper conductor identification.
    d. Proper conductor lugs and connections.
13. Exercise active components.
14. Perform phasing check on double-ended equipment to ensure proper bus phasing from each source.

B. Electrical Tests:

1. Insulation Resistance Tests:
    a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
    b. Each phase of each bus section.
    c. Phase-to-phase and phase-to-ground for 1 minute.
    d. Control wiring except that connected to solid state components.
    e. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Control Wiring:
    a. Apply secondary voltage to control power and potential circuits.
    b. Check voltage levels at each point on terminal boards and each device terminal.

3. Operational Test:
   a. Initiate control devices.
   b. Check proper operation of control system in each section.

3.04 PANELBOARDS

A. Visual and Mechanical Inspection: Include the following inspections and related work:

1. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up-to-date drawings and panelboard schedules.
2. Exercise and perform operational tests of mechanical components and other operable devices in accordance with manufacturer’s instruction manual.
3. Check panelboard mounting, area clearances, and alignment and fit of components.
4. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer’s instructions for proper torque values.
5. Perform visual and mechanical inspection for overcurrent protective devices.

B. Electrical Tests: Include the following items performed in accordance with manufacturer’s instruction:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
   b. Each phase of each bus section.
   c. Phase-to-phase and phase-to-ground for 1 minute.
   d. With breakers open.
   e. With breakers closed.
   f. Control wiring except that connected to solid state components.
   g. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Ground continuity test ground bus to system ground.

3.05 DRY TYPE TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Physical and insulator damage.
2. Proper winding connections.
3. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
4. Defective wiring.
5. Proper operation of fans, indicators, and auxiliary devices.
6. Removal of shipping brackets, fixtures, or bracing.
7. Free and properly installed resilient mounts.
8. Cleanliness and improper blockage of ventilation passages.
9. Verify tap-changer is set at correct ratio for rated output voltage under normal operating conditions.

10. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.5 for each:
      1) Winding-to-winding.
      2) Winding-to-ground.
   b. Test Duration: 10 minutes with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
   c. Results temperature corrected in accordance with NETA ATS, Table 100.14.
   d. Temperature corrected insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
   e. Insulation resistance test results to compare within 1 percent of adjacent windings.
2. Perform tests and adjustments for fans, controls, and alarm functions as suggested by manufacturer.

3.06 LIQUID FILLED TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Physical and insulator damage
2. Proper winding connections
3. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer
4. Defective wiring
5. Proper operation of fans, indicators, and auxiliary devices
6. Effective core and equipment grounding
7. Removal of shipping brackets, fixtures, or bracing
8. Tank leaks and proper liquid level
9. Integrity and contamination of bus insulation system
10. Verify tap-changer is set at correct ratio for rated voltage under normal operating conditions.
11. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.5 for each:
      1) Winding-to-winding
      2) Winding-to-ground
   b. Test Duration: 10 minutes with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.

c. Results temperature corrected in accordance with NETA ATS, Table 100.14.
d. Temperature corrected insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
e. Insulation resistance test results to compare within 1 percent of adjacent windings.

2. Perform tests and adjustments for fans, controls, and alarm functions as suggested by manufacturer.
3. Sample insulating oil in accordance with ASTM D923 and have laboratory test for the following:
   a. Dielectric breakdown voltage in accordance with ASTM D877 or ASTM D1816
   b. Acid neutralization number in accordance with ASTM D974
   c. Interfacial tension in accordance with ASTM D971
   d. Color in accordance with ASTM D1500
   e. Visual condition in accordance with ASTM D1524
   f. Specific gravity in accordance with ASTM D1298
   g. Water content, in parts per million, in accordance with ASTM D1533
   h. Dielectric fluid test results in accordance with NETA ATS, Table 100.4.
   i. Power factor at 25 degrees C and at 100 degrees, in accordance with ASTM D924.
   j. Maximum power factor, corrected to 20 degrees C, in accordance with manufacturer's specifications.

3.07 LOW VOLTAGE CABLES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Inspect each individual exposed power cable No. 4 and larger for the following:
   a. Physical damage.
   b. Proper connections in accordance with single-line diagram.
   c. Cable bends not in conformance with manufacturer's minimum allowable bending radius where applicable.
   d. Color coding conformance with specification.
   e. Proper circuit identification.
2. Mechanical Connections for the following:
   a. Proper lug type for conductor material.
   b. Proper lug installation.
   c. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
3. Shielded Instrumentation Cables for the following:
   a. Proper shield grounding
   b. Proper terminations
   c. Proper circuit identification
4. Control Cables for the following:
   a. Proper termination
   b. Proper circuit identification
5. Cables Terminated Through Window Type CTs: Verify neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests for Conductors No. 4 and Larger:

1. Insulation Resistance Tests:
    a. Utilize 1,000-volt dc megohmmeter for 600-volt insulated conductors and 500-volt dc megohmmeter for 300-volt insulated conductors.
    b. Test each conductor with respect to ground and to adjacent conductors for 1 minute.
    c. Evaluate ohmic values by comparison with conductors of same length and type.
    d. Investigate values less than 50 megohms.
2. Continuity test by ohmmeter method to ensure proper cable connections.

C. A: Low-voltage cable tests may be performed by installer in lieu of independent testing firm.

3.08 MEDIUM-VOLTAGE CABLES, 15 kV MAXIMUM

A. Visual and Mechanical Inspection:

1. Inspect each individual exposed cable for the following:
    a. Physical damage plus jacket and insulation condition
    b. Proper connections in accordance with single-line diagram or approved submittals
    c. Proper shield grounding
    d. Proper cable support
    e. Proper cable termination
    f. Cable bends not in conformance with manufacturer's minimum allowable bending radius
    g. Proper arc and fireproofing in common cable areas
    h. Proper circuit and phase identification
2. Mechanical Connections:
    a. Proper lug type for conductor material
    b. Proper lug installation
    c. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturers
3. Conductors Terminated Through Window Type CTs: Verify neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests:

1. Insulation Resistance Tests:
    a. Utilize **[A: 2,500-volt megohmmeter for 5 kV conductors] [B: and] [C: 5,000-volt megohmmeter for 8 kV and 15 kV conductors]**.
    b. Test each cable individually with remaining cables and shields grounded.
    c. Test each conductor with respect to ground and to adjacent conductors for 1 minute.
    d. Evaluate ohmic values by comparison with conductors of same length and type.
    e. Investigate values less than 50 megohms.

2. Shield Continuity Tests:
   a. By ohmmeter method on each section of conductor.
   b. Investigate values in excess of 10 ohms per 1,000 feet of conductors.
3. Acceptance Tests:
   a. In accordance with IEEE 400, ICEA S-93-639, NEMA WC 74, ICEA S-94-649, and ICEA S-97-682 for insulated conductors.
   b. Each conductor section tested with:
   c. Splices and terminations in place but disconnected from equipment.
   d. Remaining conductors and shields grounded in accordance with IEEE 400.
   e. Apply maximum test voltage per NETA ATS, Table 100.6, based on method (DC, AC, PD or VLF) used.
   f. Measure only leakage current associated with conductor.
   g. Utilize guard ring or field reduction sphere to suppress corona at disconnected terminations.
   h. Maximum test voltage shall not exceed limits for terminators specified in IEEE 48, IEEE 386, or manufacturer's specifications.
   i. Apply test voltage in a minimum of five equal increments until maximum acceptable test voltage is reached.
   j. Increments not to exceed ac voltage rating of conductor.
   k. Record dc leakage current at each step after a constant stabilization time consistent with system charging current.
   l. Raise conductor to specified maximum test voltage and hold for 15 minutes or as specified by conductor manufacturer. Record leakage current at 30 seconds and 1 minute, and at 1-minute intervals, thereafter.
   m. Immediately following test, ground conductor for adequate time period to drain insulation stored charge.
   n. Test results evaluated on a pass/fail basis.
4. New Conductors Spliced to Existing Conductors:
   a. Prior to performing splices, high potential dc test new conductor sections.
   b. After splicing new conductors to existing conductors, disconnect existing conductors and perform the following tests:
   c. Shield continuity test.
   d. Insulation resistance test.
   e. High potential test with test voltage not to exceed 60 percent of applied acceptance dc test voltage.

3.09 METAL ENCLOSED BUSWAYS

A. Visual and Mechanical Inspection:

1. Inspect for:
   a. Proper connections.
   b. Proper bracing, suspension alignment, and enclosure ground.
   c. Check if orientation of ventilated bus provides proper cooling in accordance with manufacturer's instructions and if ventilation openings are not blocked.
   d. Proper phase relationship using continuity test.
   e. Supports at maximum allowable intervals.
2. For busways rated for outdoors, check for the following:
   a. Check bus orientation for proper location of breathers or weep-hole plugs.
   b. Removal of weep-hole plugs.

c. Proper installation of joint shields.
d. Proper operation of space heaters.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1
   b. Each phase of each bus section.
   c. Phase-to-phase and phase-to-ground for 1 minute.
   d. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Overpotential Tests:
   a. Applied **[A: ac] [B: or] [C: dc]** voltage in accordance with IEEE C37.23 and NETA ATS, Table 100.19 on busways rated above 600 volts.
   b. Phase-to-phase and phase-to-ground for 1 minute.
   c. Test results evaluated on pass/fail basis.
3. Contact Resistance Tests:
   a. At each uninsulated bus connection.
   b. On insulated bus, measure resistance of bus section and compare values with adjacent phases.

3.010 SAFETY SWITCHES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Proper blade pressure and alignment.
2. Proper operation of switch operating handle.
3. Adequate mechanical support for each fuse.
4. Proper contact-to-contact tightness between fuse clip and fuse.
5. Cable connection bolt torque level in accordance with NETA ATS, Table 100.12.
6. Proper phase barrier material and installation.
7. Verify fuse sizes and types correspond to one-line diagram or approved Submittals.
8. Perform mechanical operational test and verify interlocking system operation and sequencing.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
   b. Phase-to-phase and phase-to-ground for 1 minute on each pole.
   c. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Contact Resistance Tests:
   a. Contact resistance in microhms across each switch blade and fuse holder.
   b. Investigate deviation of 50 percent or more from adjacent poles or similar switches.

3.011 MEDIUM-VOLTAGE METAL-ENCLOSED AIR SWITCHES

A. Visual and Mechanical Inspection:

1. Proper blade pressure, alignment, and arch interrupter operation.
2. Proper operation of operating mechanism.
3. Proper contact condition.
4. Adequate mechanical support for each fuse.
5. Proper contact-to-contact tightness between fuse clip and fuse.
6. Bus and cable connection tightness.
7. Proper phase barrier material and installation.
8. Proper operation of indicating devices.
9. Installation of expulsion limiting devices on expulsion type element holders.
10. Verify fuse links and types correspond to one-line diagram or approved Submittals.
11. Perform mechanical operational test to verify interlocking system operation and sequencing.
12. Perform phasing check on double-ended air switch arrangements to ensure proper bus phasing from each source.

B. Electrical Tests:

1. Insulation Resistance Tests:
    a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
    b. Phase-to-phase and phase-to-ground for 1 minute on each pole.
    c. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Contact Resistance Tests:
    a. Contact resistance in microhms across each switch blade and fuse holder.
    b. Investigate values exceeding 500 microhms or deviation of 50 percent or more from adjacent poles or similar switches.
3. Overpotential Tests:
    a. Applied **[A: ac]** **[B: or]** **[C: dc]** voltage in accordance with NETA ATS, Table 100.19.
    b. Phase-to-phase and phase-to-ground for 1 minute.
    c. Test results evaluated on pass/fail basis.

3.12 MOLDED AND INSULATED CASE CIRCUIT BREAKERS

A. General: Inspection and testing limited to circuit breakers rated 100 amperes and larger and to motor circuit protector breakers rated 100 amperes and larger.

B. Visual and Mechanical Inspection:

1. Proper mounting.
2. Proper conductor size.
3. Feeder designation according to nameplate and one-line diagram.
4. Cracked casings.
5. Connection bolt torque level in accordance with NETA ATS, Table 100.12.
6. Operate breaker to verify smooth operation.

7. Compare frame size and trip setting with circuit breaker schedules or one-line diagram.
8. Verify that terminals are suitable for 75 degrees C rated insulated conductors.

C. Electrical Tests:

1. Insulation Resistance Tests:
    a. Utilize 1,000-volt dc megohmmeter for 480-volt and 600-volt circuit breakers and 500-volt dc megohmmeter for 240-volt circuit breakers.
    b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
    c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
    d. Test values to comply with NETA ATS, Table 100.1.
2. Contact Resistance Tests:
    a. Contact resistance in microhms across each pole.
    b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
3. Primary Current Injection Test to Verify:
    a. Long-time minimum pickup and delay.
    b. Short-time pickup and delay.
    c. Ground fault pickup and delay.
    d. Instantaneous pickup by run-up or pulse method.
    e. Trip characteristics of adjustable trip breakers shall be within manufacturer's published time-current characteristic tolerance band, including adjustment factors.
    f. Trip times shall be within limits established by NEMA AB 4, Table 5-3. Alternatively, use NETA ATS, Table 100.7.
    g. Instantaneous pickup value shall be within values established by NEMA AB 4, Table 5-4. Alternatively, use NETA ATS, Table 100.8.

3.13 LOW VOLTAGE POWER CIRCUIT BREAKERS

A. Visual and Mechanical Inspection:

1. Proper mounting, cell fit, and element alignment.
2. Proper operation of racking interlocks.
3. Check for damaged arc chutes.
4. Proper contact condition.
5. Bolt torque level in accordance with NETA ATS, Table 100.12.
6. Perform mechanical operational and contact alignment tests in accordance with manufacturer's instructions.
7. Check operation of closing and tripping functions of trip devices by activating ground fault relays, undervoltage shunt relays, and other auxiliary protective devices.
8. Verify primary and secondary contact wipe, gap setting, and other dimensions vital to breaker operation are correct.
9. Check charging motor, motor brushes, associated mechanism, and limit switches for proper operation and condition.
10. Check operation of electrically operated breakers in accordance with manufacturer's instructions.
11. Check for adequate lubrication on contact, moving, and sliding surfaces.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize 1,000-volt dc megohmmeter for 480-volt and 600-volt circuit breakers.
   b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
   c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
   d. Test values to comply with NETA ATS, Table 100.1.
2. Contact Resistance Tests:
   a. Contact resistance in microhms across each pole.
   b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
3. Primary Current Injection Test to Verify:
   a. Long-time minimum pickup and delay.
   b. Short-time pickup and delay.
   c. Ground fault pickup and delay.
   d. Instantaneous pickup by run-up or pulse method.
   e. Trip characteristic when adjusted to setting sheet parameters shall be within manufacturer's published time-current tolerance band.

3.14 MEDIUM-VOLTAGE AIR CIRCUIT BREAKERS

A. Visual and Mechanical Inspection:

1. Proper cell fit and element alignment.
2. Proper operation of cubicle shutters and racking mechanism.
3. Proper contact condition.
4. Bolt torque level in accordance with NETA ATS, Table 100.12.
5. Perform mechanical operator and contact alignment tests on breaker and its operating mechanism in accordance with manufacturer's instructions.
6. Verify primary and secondary contact wipe, gap setting, and other dimensions vital to breaker operations are correct.
7. Ensure maintenance devices are available for servicing and operating breaker.
8. Check for adequate lubrication on contact, moving, and sliding parts.
9. Check condition of brushes and limit switches on charging and lifting motors.
10. With breaker in TEST position:
    a. Trip and close breaker with control switch.
    b. Trip breaker by manually operating each protective relay.
11. Perform breaker travel and velocity analysis in accordance with manufacturer's instructions; values shall be in accordance with manufacturer's acceptable limits.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize 2,500-volt dc megohmmeter for **[A: 5-kV] [B: and] [C: 15-kV]** circuit breakers.
   b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
   c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
   d. Test values to comply with NETA ATS, Table 100.1.
2. Contact Resistance Tests:

a. Contact resistance in microhms across each pole.
b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.

3. Overpotential Tests:
   a. Maximum applied **[D: ac] [E: or] [F: dc]** voltage in accordance with NETA ATS, Table 100.19.
   b. Each pole-to-ground with other poles grounded and contacts closed for 1 minute.
   c. Test results evaluated on pass/fail basis.
4. Minimum pickup voltage tests on trip and close coils.
5. Control Wiring Tests: Insulation resistance test at 1,000 volts dc on control wiring except that connected to solid state components. Insulation resistance to be 1 megohm minimum.
6. Power factor test on each phase with breaker in both OPEN and CLOSED positions. Compare power factor and arc chute watt loss with adjacent poles or manufacturer’s published data.
7. Power factor test on each bushing utilizing conductive straps and hot collar procedures if bushings are not equipped with power factor tap. Power factor and capacitance test results within nameplate rating of bushings.

3.15 MEDIUM-VOLTAGE VACUUM CIRCUIT BREAKERS

A. Visual and Mechanical Inspection:

1. Check for proper element alignment.
2. Check for proper operation of cubicle shutters and racking mechanism.
3. Bolt torque level in accordance with NETA ATS, Table 100.12.
4. Perform mechanical operational tests on breaker and its operating mechanism in accordance with manufacturer’s instructions, plus check:
   a. Pull rod adjustment.
   b. Trip latch clearance.
   c. Overtravel stops.
   d. Wipe and gap setting.
5. Perform breaker travel and velocity analysis in accordance with manufacturer’s instructions; values shall be in accordance with manufacturer’s acceptable limits.
6. Check contact erosion indicators in accordance with manufacturer’s instructions.
7. With breaker in TEST position:
   a. Trip and close breaker with control switch.
   b. Trip breaker by manually operating each protective relay.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize 2,500-volt dc megohmmeter for **[A: 5-kV] [B: and] [C: 15-kV]** circuit breakers.
   b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
   c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
   d. Test values to comply with NETA ATS, Table 100.1.

2. Contact Resistance Tests:
   a. Between the line and load stab of closed contact resistance in microhms across each pole.
   b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
3. Overpotential Tests:
   a. Maximum applied **[D: ac]** **[E: or]** **[F: dc]** voltage in accordance with NETA ATS, Table 100.19.
   b. Each pole-to-ground with other poles grounded and contacts closed for 1 minute.
   c. Test results evaluated on pass/fail basis.
4. Minimum pickup voltage tests on trip and close coils.
5. Control Wiring Tests:
   a. Insulation resistance test at 1,000-volt dc on control wiring, except that connected to solid state components.
   b. Insulation resistance to be 1 megohm minimum.
6. Vacuum bottle overpotential integrity test across each vacuum bottle with breaker in OPEN position, in accordance with manufacturer's instructions.
7. Power Factor Test (Each Phase):
   a. With breaker in both OPEN and CLOSED position.
   b. Compare power factor and arc chute watt loss with adjacent poles or manufacturer's published data.
8. Power Factor Test (Each Bushing):
   a. Utilize conductive straps and hot collar procedures if bushings are not equipped with power factor tap.
   b. Power factor and capacitance test results within nameplate rating of bushings.

3.16 PROTECTIVE RELAYS

A. Visual and Mechanical Inspection:

1. Visually check each relay for:
   a. Tight cover gasket and proper seal.
   b. Unbroken cover glass.
   c. Condition of spiral spring and contacts.
   d. Disc clearance.
   e. Condition of case shorting contacts if present.
2. Mechanically check each relay for:
   a. Freedom of movement.
   b. Proper travel and alignment.
3. Verify each relay:
   a. Complies with Contract Documents, approved Submittal, and application.
   b. Is set in accordance with recommended settings from Coordination Study.

B. Electrical Tests:

1. Insulation resistance test on each circuit to frame, except for solid state devices.
2. Test on nominal recommended setting for:
   a. Pickup parameters on each operating element.

b. Timing at three points on time-current curve.
c. Pickup target and seal-in units.
d. Special tests as required to check operation of restraint, directional, and other elements in accordance with manufacturer's instruction manual.

3. Phase angle and magnitude contribution tests on differential and directional relays after energization to vectorially verify proper polarity and connections.
4. Current Injection Tests:
   a. For entire current circuit in each section.
   b. Secondary injection for current flow of 1 ampere.
   c. Test current at each device.

3.17 INSTRUMENT TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Visually check current, potential, and control transformers for:
   a. Cracked insulation.
   b. Broken leads or defective wiring.
   c. Proper connections.
   d. Adequate clearances between primary and secondary circuit wiring.
2. Verify mechanically:
   a. Grounding and shorting connections have good contact.
   b. Withdrawal mechanism and grounding operation, when applicable, operate properly.
3. Verify proper primary and secondary fuse sizes for potential transformers.

B. Electrical Tests:

1. Current Transformer Tests:
   a. Insulation resistance test of transformer and wiring-to-ground at 1,000 volts dc for 30 seconds.
   b. Polarity test.
2. Potential Transformer Tests:
   a. Insulation resistance test at test voltages in accordance with NETA ATS, Table 100.9, for 1 minute on:
      1) Winding-to-winding.
      2) Winding-to-ground.
   b. Polarity test to verify polarity marks or H1-X1 relationship as applicable.
3. Insulation resistance measurement on instrument transformer shall not be less than that shown in NETA ATS, Table 100.5.

3.18 METERING

A. Visual and Mechanical Inspection:

1. Verify meter connections in accordance with appropriate diagrams.
2. Verify meter multipliers.
3. Verify meter types and scales conform to Contract Documents.
4. Check calibration of meters at cardinal points.

5. Check calibration of electrical transducers.

3.19 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:

1. Equipment and circuit grounds in motor control center, panelboard, switchboard, and switchgear assemblies for proper connection and tightness.
2. Ground bus connections in motor control center, panelboard, switchboard, and switchgear assemblies for proper termination and tightness.
3. Effective transformer core and equipment grounding.
4. Accessible connections to grounding electrodes for proper fit and tightness.
5. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.

B. Electrical Tests:

1. Fall-of-Potential Test:
   a. In accordance with IEEE 81, Section 8.2.1.5 for measurement of main ground system's resistance.
   b. Main ground electrode system resistance to ground to be no greater than 3 ohm(s).
2. Two-Point Direct Method Test:
   a. In accordance with IEEE 81, Section 8.2.1.1 for measurement of ground resistance between main ground system, equipment frames, and system neutral and derived neutral points.
   b. Equipment ground resistance shall not exceed main ground system resistance by 0.50 ohm.
3. F: Neutral Bus Isolation:
   a. Test each neutral bus individually with neutral bonding jumper removed at service entrance or separately derived system.
   b. Evaluate ohmic values by measuring resistance between ground bus and neutral bus.
   c. Investigate values less than 50 megohms.

3.19 GROUND FAULT SYSTEMS

A. Inspection and testing limited to:

1. Zero sequence grounding systems.
2. Residual ground fault systems.

B. Visual and Manual Inspection:

1. Neutral main bonding connection to ensure:
   a. Zero sequence sensing system is grounded ahead of neutral disconnect link.
   b. Ground strap sensing system is grounded through sensing device.
   c. Neutral ground conductor is solidly grounded.
2. Verify control power has adequate capacity for system.

3. Manually operate monitor panels for:
    a. Trip test
    b. No trip test
    c. Nonautomatic rest
4. Zero sequence system for symmetrical alignment of core balance transformers about current carrying conductors.
5. Relay check for pickup and time under simulated ground fault conditions.
6. Verify nameplate identification by device operation.

C. Electrical Tests:

1. Test system neutral insulation resistance with neutral ground link removed; minimum 1 megohm.
2. Determine relay pickup by primary current injection at the sensor. Relay pickup current within plus or minus 10 percent of device dial or fixed setting.
3. Test relay timing by injecting 300 percent of pick-up current or as specified by manufacturer. Relay operating time in accordance with manufacturer's time-current characteristic curves.
4. Test system operation at 55 percent rated control voltage, if applicable.
5. Test zone interlock system by simultaneous sensor current injection and monitoring zone blocking functions.

3.20 AC INDUCTION MOTORS

A. General: Inspection and testing limited to motors rated 5 horsepower and larger.

B. Visual and Mechanical Inspection:

1. Proper electrical and grounding connections
2. Shaft alignment
3. Blockage of ventilating air passageways
4. Operate motor and check for:
    a. Excessive mechanical and electrical noise
    b. Overheating
    c. Correct rotation
    d. Check vibration detectors, resistance temperature detectors, or motor inherent protectors for functionability and proper operation.
    e. Excessive vibration, in excess of values in NETA ATS, Table 100.10.
5. Check operation of space heaters.

C. Electrical Tests:

1. Insulation Resistance Tests:
    a. In accordance with IEEE 43 at test voltages established by NETA ATS, Table 100.1 for:
        1) Motors above 200 horsepower for 10-minute duration with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
        2) Motors 200 horsepower and less for 1-minute duration with resistances tabulated at 30 seconds and 60 seconds.

b. Insulation resistance values equal to, or greater than, ohmic values established by manufacturers.

2. Calculate polarization index ratios for motors above 200 horsepower. Investigate index ratios less than 1.5 for Class A insulation and 2.0 for Class B insulation.
3. Insulation resistance test on insulated bearings in accordance with manufacturer's instructions.
4. Measure running current and voltage, and evaluate relative to load conditions and nameplate full-load amperes.

3.21 LOW-VOLTAGE MOTOR CONTROL

A. Visual and Mechanical Inspection:

1. Proper barrier and shutter installation and operation.
2. Proper operation of indicating and monitoring devices.
3. Proper overload protection for each motor.
4. Improper blockage of air-cooling passages.
5. Proper operation of drawout elements.
6. Integrity and contamination of bus insulation system.
7. Check door and device interlocking system.
8. Check nameplates for proper identification of:
   a. Equipment title and tag number with latest one-line diagram.
   b. [M: Pushbuttons.]
   c. [N: Control switches.]
   d. [O: Pilot lights.]
   e. [P: Control relays.]
   f. [Q: Circuit breakers.]
   g. [R: Indicating meters.]

9. Verify fuse and circuit breaker sizes and types conform to Contract Documents.
10. Verify current and potential transformer ratios conform to Contract Documents.
11. Check bus connections for high resistance by low-resistance ohmmeter.
12. Check operation and sequencing of electrical and mechanical interlock systems by:
    a. Closure attempt for locked open devices.
    b. Opening attempt for locked closed devices.
    c. Key exchange to operate devices in OFF-NORMAL positions.
13. Verify performance of each control device and feature furnished as part of motor control center.
14. Control Wiring:
    a. Compare wiring to local and remote control, and protective devices with elementary diagrams.
    b. Check for proper conductor lacing and bundling.
    c. Check for proper conductor identification.
    d. Check for proper conductor lugs and connections.
15. Exercise active components.
16. Inspect contactors for:
    a. Correct mechanical operations.
    b. Correct contact gap, wipe, alignment, and pressure.
    c. Correct torque of connections.
17. Compare overload heater rating with full-load current for proper size.

18. Compare **[A: fuse] [B: motor protector] [C: and] [D: circuit breaker]** with motor characteristics for proper size.
19. Perform phasing check on double-ended motor control centers to ensure proper bus phasing from each source.

B. Electrical Tests:

1. Insulation Resistance Tests:
    a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
    b. Bus section phase-to-phase and phase-to-ground for 1 minute on each phase.
    c. Contactor phase-to-ground and across open contacts for 1 minute on each phase.
    d. Starter section phase-to-phase and phase-to-ground on each phase with starter contacts closed and protective devices open.
    e. Test values to comply with NETA ATS, Table 100.1.
2. Current Injection through Overload Unit at 300 Percent of Motor Full-Load Current and Monitor Trip Time:
    a. Trip time in accordance with manufacturer's published data.
    b. Investigate values in excess of 120 seconds.
3. Control Wiring Tests:
    a. Apply secondary voltage to control power and potential circuits.
    b. Check voltage levels at each point on terminal board and each device terminal.
    c. Insulation resistance test at 1,000 volts dc on control wiring, except that connected to solid state components; 1 megohm minimum insulation resistance.
4. Operational test by initiating control devices to affect proper operation.

3.22 LOW VOLTAGE SURGE ARRESTORS

A. Visual and Mechanical Inspection:

1. Adequate clearances between arrestors and enclosures.
2. Ground connections to ground bus.

B. Electrical Tests:

1. Varistor Type Arrestors:
    a. Clamping voltage test
    b. Rated RMS voltage test
    c. Rated dc voltage test
    d. Varistor arrestor test values in accordance with IEEE C62.33, Section 4.4 and Section 4.9

3.23 MEDIUM-VOLTAGE SURGE ARRESTORS AND SURGE CAPACITORS

A. Visual Inspection:

1. Ground connections to ground **[A: bus] [B: electrode]**
2. Shortest practical jumper connections to line.

B. Electrical Tests:

1. Grounding electrode resistance test in accordance with IEEE 81, Section 8.2.1.5 using three-point fall-of-potential method.
2. Insulation power factor.
3. Insulation resistance.
4. RF noise test using Stoddart noise test set with applied voltage of 1.18 times maximum continuous operating voltage.
5. Insulation power factor leakage current, watts loss, and insulation resistance test in accordance with manufacturer’s test values. RIV value not to exceed 10 microvolts above background noise.
6. Leakage current and watts loss tests.

END OF SECTION

SECTION 26 99 99 – ELECTRICAL TESTING

PART 1 - GENERAL

1.01 DESCRIPTION

A. This section includes a summary of the electrical testing requirements necessary for the acceptance of electrical equipment and installations as well as one copy of a test report form which shall be attached to each test result reported.

B. The purpose of the specified tests and inspections is to determine that each piece of equipment is in satisfactory condition to successfully perform its intended function.

C. It is the intent of these procedures to ensure that all workmanship, materials, the manner and method of erection, and installation conform to manufacturer's instructions and, except as modified herein, the National Electrical Code, Institute of Electrical and Electronic Engineers, American National Standards Institute, American Society for Testing and Materials, Underwriters' Laboratories, Inc., National Electrical Manufacturers Association, and Association of Edison Illuminating Companies Standards.

1.02 SUBMITTALS

A. A report for each test performed shall be submitted to the CONTRACTOR'S PROJECT REPRESENTATIVE for approval.

B. Each report shall be submitted along with the form shown in Attachment A.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.01 RESPONSIBILITY

A. The subcontractor shall perform and supervise all tests unless specifically noted otherwise herein or on the drawings. The subcontractor shall furnish all test equipment required for the tests performed and shall be responsible for providing such safety measures as are required for each test.

B. The subcontractor shall schedule all testing with the CONTRACTOR or DESIGNATED PROJECT REPRESENTATIVE, and no testing of any kind shall be performed without CONTRACTOR approval.

C. The subcontractor shall notify all involved parties prior to test advising them of the test to be performed and the scheduled date and time.

D. The subcontractor shall give manufacturers sufficient notice to allow the necessary arrangements to be made and to have their engineer or representative present at tests where their presence is required. Where the manufacturer's responsibility includes both electrical and mechanical performance, the subcontractor shall coordinate the tests with the others involved.

E. The subcontractor shall furnish all test equipment required to perform the tests for which he is responsible. For test instruments to be acceptable for use, they must bear a label documenting the fact that the equipment has been calibrated during the previous 12 months. The label must show instrument serial number, date of calibration, and name of firm or laboratory performing calibration.

F. The CONTRACTOR or DESIGNATED PROJECT REPRESENTATIVE will examine the subcontractor's test equipment prior to use and may require that the equipment be submitted to the CONTRACTOR for a calibration check. Equipment that fails to be within acceptable limits must be submitted by the subcontractor to an approved testing laboratory for proper calibration. The subcontractor must then submit evidence of proper calibration.

3.02 FIELD QUALITY CONTROL

A. Test Reports

1) The subcontractor shall perform all tests listed in these specifications and shall submit a formal test report for each test conducted. Each test report shall contain, at a minimum, the following information:

a. Job title
b. Date of test
c. Equipment, system, or cable identification
d. Specific type of test
e. Description of test instrument and date of calibration
f. Section of specification defining test
g. Test results (correct all insulation-resistance readings to 20ºC)
h. Signature of person supervising test
i. Signature of subcontractor Representative
j. Space for CONTRACTOR or DESIGNATED PROJECT REPRESENTATIVE signature

2) Subcontractor test reports shall be submitted along with a completed Electrical Test Report form (Attachment A). Upon completion of each test or series of similar tests, the subcontractor shall complete the test report(s) and submit them for approval within five working days after the testing is performed.

B. Acceptance

1) Acceptance of all electrical equipment and cables covered by test procedures shall be contingent upon proper execution of the required tests and acceptable test results.

2) Acceptance of all electrical equipment shall be dependent upon each piece of equipment satisfactorily performing its intended function.

END OF SECTION

ATTACHMENT A
ELECTRICAL TEST REPORT

THIS TEST REPORT IS TO BE SUBMITTED FOR TESTING OF POWER CABLE, GROUND GRIDS, ETC., AND ELECTRICAL EQUIPMENT, SUCH AS TRANSFORMERS, SWITCHGEAR, ETC.

JOB TITLE:____

TEST REPORT NO.:______________________________DATE:_______________________________

PROJECT ID.____________________________________BLDG/AREA:___________________________

WEATHER CONDITIONS:________________________SOIL CONDITIONS:______________________

EQUIPMENT, DESCRIPTION, LOCATION, AND NAMEPLATE DATA:

____

____

____

DESCRIPTION OF TEST:____

SECTION OF SPECIFICATION DEFINING TEST:____

ACCEPTABLE VALUE: MIN.___________________________MAX.____________________________

TEST INSTRUMENT

MODEL NO.____CALIBRATION DATE:_____________

TESTING RESULTS AND NOTES: (REFERENCE ATTACHMENTS AS REQUIRED)

____

____

____

____

TEST PERFORMED BY _________________________________COMPANY_______________________

TEST SUPERVISED BY ________________________________COMPANY_______________________

TEST WITNESSED BY _________________________________COMPANY_______________________

CONTRACT PROJECT REPRESENTATIVE

APPENDIX C

MEMORANDUM: GROUNDWATER EXTRACTION WELL REQUIREMENT, BUILDING C-400 PHASE IIB TREATABILITY STUDY, PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY

THIS PAGE INTENTIONALLY LEFT BLANK

Memorandum

Environmental
Resources
Management

2875 Michelle Drive
Suite 200
Irvine CA, 92606
(949) 623-4700
(949) 623-4711 (fax)

To: Michael Clark, LATA Environmental of KY, LLC
Jeff Carman, LATA Environmental of KY, LLC

From: Jay Dablow, P.G., C.E.G., ERM
Ron Falta, Falta Environmental

Date: 12 November 2013

Subject: Conceptual Evaluation of a Groundwater Extraction Well for the Building C-400 Phase IIb Treatability Study
Paducah Gaseous Diffusion Plant
Paducah, KY

This technical memorandum provides a justification for eliminating the installation of a groundwater extraction well at the Paducah Gaseous Diffusion Plant. The following is submitted as justification for this request.

- The steam injection Phase IIb Treatability Study (treatability study) is designed to collect data that can be used to estimate the horizontal and vertical hydraulic conductivities of the Regional Gravel Aquifer (RGA), and to provide heating performance data that can be used in the design of a full-scale Steam Enhanced Extraction (SEE) system. The treatability study involves steam injection into a single areal location, at one or two depths in the RGA, with varying steam injection rates. The subsurface temperature in the RGA will be measured at various distances and elevations throughout the test to show the arrival of the steam front. The maximum radial extent of steam migration during this test will be limited to approximately 20 feet, as determined by the temperature monitoring system.

- It is well-established that trichloroethylene (TCE) is effectively removed by SEE processes; therefore this test focuses solely on understanding the steam front movement. Given this objective, the treatability study does not include vapor extraction wells, and contaminants are not being removed as part of the test.

- It has been suggested that a downgradient groundwater extraction well might be installed and operated as a part of this treatability study. It is our opinion that such a well is not necessary, and will add greatly to the cost and complexity of running the study.

- The purpose of a downgradient groundwater extraction well would be to capture any mobilized contaminants. However, due to the properties of TCE, and to the nature of the treatability study, we do not anticipate any significant contaminant mobilization as a result of the study. As TCE, or water containing TCE is heated, the TCE becomes

A member of the Environmental Resources Management Group

more volatile, and has an increasing tendency to partition into the vapor phase. The aqueous solubility of TCE, however, only increases modestly with increased temperature. The solubility of TCE was recently measured over a temperature range of 8°Celsius (C) to 75°C, and it was found that TCE solubility only increased by 23 percent over this considerable temperature range (Chen et al., 2012[1]).

- A small degree of localized TCE redistribution may occur during the steam treatability study. As steam is injected, any TCE present in the steam zone will boil or volatilize and move towards the steam front, where the steam vapor condenses back into liquid water. Because the tests will be terminated when the steam front reaches a maximum distance of approximately 20 feet, any redistribution of contaminants would be expected to be limited to this distance from the injection well. After the steam injection is stopped, the steam zone will cool, and collapse back to a liquid water system.
- The treatability study is going to be performed within the volume of the RGA contained within the capture zone of the existing groundwater pump-and-treat system.

Based on the justification above, ERM believes that the groundwater extraction well is not required for successful completion of the treatability study.

Thank you for considering this request. Please inform us of your decision at your earliest convenience. If you have any questions, please contact Mr. Jay Dablow at 714-606-9110.

Jay Dablow, P.G.
Technical Fellow, Partner

JD/RF/taa-0222972.01

[1] Chen, F., D.L. Freedman, R.W. Falta, and L.C. Murdoch, 2012, Henry's Law Constants of Chlorinated Solvents at Elevated Temperatures, *Chemosphere, Vol. 86, No. 2, p. 156-165*