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48 00 00 ELECTRICAL POWER GENERATION (AND ALLIED FACILITIES)

48 01 01. Operations & Maintenance

.1 INTRODUCTION: To a large extent the success of any great institution depends on the strength and durability of its infrastructure. A key element of the University infrastructure is its utilities. Electricity plays a vital role in almost every aspect of the University experience from housing through academics and sports to research and allied institutions such as the medical center. Our mission in Utility High Voltage Services (UTHVS) is to provide quality of service and continuity of service with a principal focus on public and employee safety.

The Electric utility infrastructure performance relies on ***Maintenance***, ***Equipment Performance*** and ***Human Performance***.

Human Performance relies on training, standards (design consistency), and reliable equipment (good maintenance, sound design).

Equipment performance relies on sound design, quality components, and sound maintenance practices.

Good Maintenance relies on sound planning, quality components, sound design, and reliable human performance.

No element stands alone. No one element can be sustained without the others. No one element can compensate for the absence of another. This Division of the Building Design Standards sets forth unique requirements applied to address the equipment performance, human performance and maintenance needs of the utility high voltage infrastructure of the University. These requirements should be used in conjunction with the remainder of the University BDS to arrive at a design and implementation that meets the full utility performance expectation of the University and its allied institutions.

.2 SCOPE OF APPLICABILIITY: This document provides the requirements and preferred practices of the University as they apply to the McCracken Power Plant and allied facilities such as chemical storage areas, water treatment, standby generation, fuel supply systems and facilities, central chiller and central steam generation facilities and temporary facilities such as portable generation, package boilers etc.

OSU maintains and operates its own utility plants and standby generators. The plants supply steam, chilled water, domestic hot water and compressed air to the University. The scope of application of this document is limited to the above mentioned facilities, and allied facilities. It covers the design and operation of these facilities, for power system equipment and associated controls and protection. Guidance for the design and operation of the electrical systems for the building office space, unless otherwise noted in this document, is contained in Division 26 of the Building Design Standards.

The practices and conventions referenced herein and applied throughout the design of the Medium Voltage Distribution System and its allied facilities are the product of an engineering process directed toward optimizing safe and reliable operations. Compliance with OSHA and National Electric Safety Code requirements is fundamental. Compliance with the National Electric Code is not a design requirement and shall be invoked only on a case by case basis, conformant to the Code applicability statements and where technically useful in obtaining Utilities objectives for overall facility safety and reliability.

A/E and Contractor provisions of this document are intended to promote work practices that:

- Adhere in all their procurement and work practices to the OSU Utilities Project Construction Quality Plan
- Conform their construction practices to the OSU Utilities Project Safety and Health Guide

This Division of the Building Design Standard makes reference to various codes and standards. In all cases where there is an apparent conflict between this document and these other referenced documents the requirements of this document shall govern.

48 02 00 CONFIGURATION MANAGEMENT

48 02 01. Drawing System

.1 INTRODUCTION: Utilities maintains a design drawing system as part of the overall Configuration Management program. The drawing system is used to facilitate maintenance, troubleshooting, and to serve as a resource for planning and engineering upgrades and changes to the power plant, substations, and high voltage distribution system. Keeping the drawings in this system accurate, current, and complete can greatly reduce system downtime and improve power system reliability and availability. It also directly affects personnel training, personnel performance and productivity.

.2 DRAWING PLATFORM: The electrical drawing system is made up of a set of specialized drawing types. The types are designed to document and there by facilitate the control of the configuration of various portions of the electrical power system and related equipment; their protection and their control, and monitoring features. Certain projects may require specialized drawings. In general, the drawings maintained by UTHVS fall into four broad categories: One-lines, Schematics, interconnection, and physical layout. The drawings are maintained in AutoCAD.

Utility High Voltage Services maintains or contributes to the maintenance of: Electrical One Line Diagrams for the bulk power and 13.2 KV Primary power distribution, 480 and 208 VAC, 125 VDC; Quad drawings, circuit schematics (data tables); Manhole diagrams and Circuit Risers for the 13.2 KV feeder pairs, and underground. Elementary Schematic drawings for metering and power equipment control and protection; Interconnection diagrams and logics for integrated control systems and interlocking.

The electrical one line diagrams show power sources, major power equipment, their ratings and connections. They also show metering and protection, instrument transformers, major loads, reactors, capacitors, surge arrestors, fuses, circuit breakers, switches, grounding, phasing, and voltage levels present.

Quad drawings are drawings that show the physical layout of the campus overlaid by a specific Primary Circuit Feeder pair. It is a scaled drawing form that shows each manhole and connecting duct bank routing.

Circuit schematics (data tables) show individual Primary Circuits Pairs as a series of duct bank sections and manholes from the substation power source to the extreme ends of the circuits including all branches. These documents also show cable sizes, cable lengths, duct bank occupancy and cable installation dates.

Manhole diagrams show the manhole conduit contents and status for all four walls in a physical portrayal but not to scale. They also show circuit numbers and building lateral destinations.

Circuit riser diagrams DWG 999 E1015 (GE One-lines) are a form of One line diagram used specifically to show Primary Circuit Taps, their associated manholes and the Primary Select switches and Primary transformers. They show Primary disconnects and the various switching arrangements belonging to the buildings powered from the Primary Circuit pairs. They also contain fuse data for the Primary transformer feeds.

Elementary Schematic drawings show in schematic rather than physical sense, the arrangement and logic involved in both the power connections and switching as well as the logic and components used in design of the control and protection circuitry. They contain the nomenclature used to identify all electrical components as well as the control instruments and interface components such as transmitters, motor operated valves, solenoid valves, positioners, hydraulics, pneumatics etc... They also contain references to vendor supplied drawings, documents and interconnection diagram wire references. Switch and relay contact developments are included on the elementaries to facilitate understanding the control logic.

Interconnection diagrams show how equipment and systems are interconnected (wired and cabled). They may or may not show the relative physical orientation of components. Interconnection, wiring diagrams and or wiring tables give specific information on how equipment is wired on a wire by wire basis and identify physical location and associated reference drawing.

Logic diagrams show the logic used for the control interlocking and protection of equipment and systems. They are primarily schematic and show little or no physical detail other that physical location and elevation.

One lines, elementary/schematics and interconnection/logic diagrams are meant to work as a system, meaning they are cross referenced and contain complimentary information. Duplication of information between drawing types is held to a minimum level needed to facilitate moving between the various drawing types. Each type is designed to assist in accomplishing specific engineering and electrician tasks.

Drawing nomenclature, conventions, and symbology may vary from drawing to drawing. To the extent practical, electrical drawings use nomenclature, conventions, and symbology reflecting general practice in the utility industry.

.3 DRAWING SYSTEM NUMBERING: This drawing numbering system pertains to design, construction and operating drawings documenting designs and as-installed conditions in the Substations and Centralized steam plants and chilled water plants and allied facilities on the OSU Columbus Campus. The system may be applied after record drawings are submitted at the completion of a project or its utilization may be required of the Design Associate at the beginning of a project, in which case the drawing numbering will carry through from CD throughout the life of the facility. See drawing naming requirements at:

http://fod.osu.edu/proj_del/ref/Electronic_Drawing_Naming_Req.doc

.3.1 Administration:

A master list (data base) shall be maintained current by the Utilities Division and contain the drawing number, the drawing title, the associated project, the revision number, and the organizational unit responsible for the maintenance of the drawing.

.3.2 Effective Date:

The drawing system was placed in force for all projects issuing CD drawings on and after January 1, 2007 and was applied earlier at the discretion of the Director of Utilities as seen fit to facilitate projects already underway at that time.

.4 DRAWING MANAGEMENT

.4.1 CAD file management

The drawing system is managed as CAD files. The files are uniquely named and organized numerically by type of drawing and status (revision and approval). Superseded files are archived along with the current files and are write-protected. Working revisions in development or awaiting approval are password protected. Open revisions are controlled individually. All previous revisions are archived and kept available for reference. All current and active and revision files are maintained on network drives and subject to routine periodic back-up and archival storage.

.4.2 Hard copy access

Current and revision review files are available in electronic and hard copy form on request. Superseded revisions are available on reasonable notice.

.4.3 Inclusion of vendor information

Vendor information in the form of drawings, tables or sketches, when in a compatible format, may be incorporated directly onto the electrical drawings. Project or equipment design specific information should be incorporated into the drawing system. General information should be incorporated into training materials or instruction books and not made part of the drawing system.

.4.4 Inclusion of as-built information

Because the majority of projects are engineered and constructed by other organizations for the university, incorporation of these project files into the utility drawing system is particularly important.

Read-only design drawing files are generally acceptable up until the construction release. Construction drawing release and the release of as-built (as-constructed record drawings) drawings shall be in revisable format compatible with the Universities CAD platform. Construction release drawing files are retained within the drawing system and serve as a reference point for planning and estimating parallel projects. Final project record drawings are incorporated into the drawing system as current drawing revision “0”. An archive copy of these files shall also be retained in the respective project record files (record drawings). These revisions are separately identified and given unique drawing numbers.

.4.5 Incorporation of project drawings

Drawings prepared by an associate or contractor for a project shall be prepared with the understanding that the University may incorporate the drawing contents in their entirety or in part into the University drawing system. Drawing completeness, accuracy and drafting quality shall support this. All drawings produced during the course of a project shall become the property of the University in their native revisable and reproducible form.

.4.6 Drawing numbering and revision management

Drawings maintained in the Drawing System are uniquely identified. Each drawing is coded with its drawing type, a project sequence identifier, a title and a revision number.

.4.7 Design standards and Sketch management

The Drawing System shall maintain a set of Drafting Standards and Design Sketches. Both the Standards and the Sketches are managed like drawings, with unique titles and revision numbering.

.4.8 Drawing Index and drawing lists

The Drawing System shall incorporate a procedure governing drawing types, numbering methodology, standard nomenclature and symbology. It shall also incorporate a series of listings containing all the active (current and archived) drawings along with the current revision date. See drawing naming requirements at:

http://fod.osu.edu/proj_del/ref/Electronic_Drawing_Naming_Req.doc

.4.9 Quality Control

Drawing source material shall be reviewed and accepted for incorporation. All design and drafting work shall be subjected to a rigorous self-checking and independent check for accuracy and completeness. The independent checking shall extend to verifying that all integrated drawings have been properly coordinated, completed or revised.

.4.10 Integrated Design check

Prior to sending out a Construction Drawing set to the University for review, the Engineer shall perform an integrated design check. The design check will verify the interfacing of controls with the current mechanical and electrical drawings and equipment specifications provided.

.4.11 Approval and signature authority

Approval authority for drawings and stamped plans generated external to the University in the execution of projects by the project engineer shall be in conformance with the University process governing the issuance of project drawings.

Approval authority for internally generated drawing additions or revisions of drawings for facilities within the scope of this Standard resides with the Technical Director of Utilities. Signature authority shall be delegated via written form to any qualified member of the Utility staff. The design document shall be initialed by the drafter of record, the reviewer and approved by the Technical Director of Utilities or their designee.

48 02 02. Software, Firmware Control System

.1 INTRODUCTION: Utilities maintains a system for the control of software based information as part of the overall Configuration Management program. This Software and Firmware control system is used to facilitate maintenance, troubleshooting and to serve as a resource for planning and engineering upgrades and changes to the power plant, substations and high voltage distribution system. Included in this class of information are: Program listings, system and component set-up data, protective relay settings files, fault and coordination files, calculation files and failure data recordings. Keeping the information in this system accurate, current and complete can greatly reduce system downtime and improve power system reliability and availability. It also directly affects personnel training, personnel performance and productivity.

.2 PLATFORM: The University Utility Group can support a variety of platforms. It reserves the right to request compatibility to specific platforms when circumstances warrant.

.3 CONFIGURATION SOFTWARE: If the Utilities Division does not possess the software to configure a new PLC or controller, 3 fully licensed copies of the software must be provided with the project. Software must be Windows 7 compatible.

.4 ORGANIZATION (future work item)

Software/firmware types
File content
Standards

.5 MANAGEMENT (future work item)

File management
Hard copy access
Inclusion of vendor information
Inclusion of as-built information
Incorporation of project software, configurations and settings
File identification and revision management
Design standards and Sketch management
Index and listings

.6 QUALITY CONTROL (future work item)

.7 APPROVAL AUTHORITY (future work item)

48 02 03. Change Control

.1 CHANGE AUTHORIZATION: Work that exceeds basic maintenance and repairs or that changes the design, system operation or materials of construction in the power plant, substation, or primary distribution systems requires prior authorization of the Technical Director of Utilities or designee and qualified design oversight and inspection. This requirement applies to systems that are in operation as well as systems that are being installed to approved construction documents. Approval authority may be delegated by the Technical Director of Utilities to the construction authority for projects under construction. Approval authority may be delegated to subordinates in Utilities.

.2 WORK SCOPING AND DOCUMENT IMPACT IDENTIFICATION: The nature of the proposed changes shall be clearly defined. A technical and cost justification shall be provided. The anticipated impact on existing facility systems and equipment shall be accessed, including constructability, startup and maintenance considerations and "What if" risk assessment on equipment, systems and human failures that could result in utility outages. (See 48 09 10.9 for additional information) Compliance with OSU BDS and its appendices shall be established. Personnel training and familiarization needs as well as maintenance needs shall be outlined. The impact on drawings, procedures and practices shall be described. A Failure Modes and Effects Assessment shall be provided for use in determining the potential impact on the design of facilities, structures, support systems and utilities as well as the acceptability of the consequences of a failure.

48 02 04. Work control

.1 DEVICE AND CABLE NUMBER ASSIGNMENT: Unique device and cable numbers shall be assigned according to Utilities naming and numbering conventions.

.2 DRAWINGS: All work shall be installed to original issued signed and stamped drawings, approved marked-up drawings or detailed sketches. New drawings and sketches shall conform to Utility practices for content and information organization. Installation using pre-approved marked-up University drawings is acceptable if the mark-ups show adequate detail to be used to control the installers' materials and practices and present a usable and complete record of the final installation.

.3 QC CHECK POINTS: The installation shall proceed with preplanned hold points to allow for work inspection by the Utility or an independent third party inspection and test agency. All critical tasks shall be done by qualified trained personnel.

.4 ELECTRICAL INSPECTION: Electrical inspection for completeness and compliance to the BDS, Code, Good Practices and the Design shall be performed on a regular basis for the various portions of the installation as the project progresses. This may be performed by the prime contractor, Utility personnel, or an independent agency. However, the responsibility for seeing that this function is performed to the satisfaction of UTHVS rests with the prime contractor. Discrepancies and omissions shall be followed up and corrected in a thorough and timely fashion. Reference construction inspection checklists for primary electric service, when applicable.

.5 CHECKOUT AND COMMISSSIONG: There shall be a formal independent check-out and commissioning process. This activity shall be pre-planned and thoroughly documented. All test and calibration equipment shall be National Institute of Standards and Technology (NIST) (or Utility approved and appropriate agency) traceable.

Checkout shall verify all protection, interlocking, control functions, and alarming are operational and to spec.

Commissioning shall demonstrate that all systems are operational (meet fitness for use requirements); personnel are trained in operation and maintenance.

Third party involvement for the checkout and commissioning of Medium voltage equipment and systems shall be by a qualified Relay Checkout Organization (RCO) with a documented history of successfully conducting such work and staffed at a technical level adequate to perform an engineering review of the design as or if required.

Third party involvement for the checkout and commissioning of Low voltage equipment and systems shall be by a qualified Independent testing service (ITS) with a documented history of successfully conducting such work.

.6 JOB STATUS TRACKING: Status and tracking shall be appropriate to the size and complexity of the project. At a minimum all changes shall have their approval, implementation and documentation status recorded and tracked; open items and follow up activities noted.

.7 DOCUMENT UPDATES, RECORD DRAWING RELEASE AND AS-BUILTS: All University documents impacted by the change shall be updated. Project drawings shall be updated and kept current with as installed conditions and at completion of project, incorporated into the appropriate University drawing system. Vendor supplied documents with maintenance, trouble shooting, and operation of equipment information shall be assembled and included in the Project O&M Manuals and retained in the University Vendor Document Control System.

.8 PROJECT CLOSE-OUT PACKAGE: Each change shall have a close-out package on file that contains the scoping and authorization documents, as-built record drawings, supporting vendor and technical correspondence, catalog information and, Project O&Ms. The package shall also contain a record of the change being functionally tested and released for operation.

A record of training along with training materials shall be included. Reference Project Closeout:

http://www.fod.ohio-state.edu/proj_del/index.htm

48 03 00 DESIGN REQUIREMENTS

Requirements of this Standard are based on good engineering practice and provide a uniform and consistent basis for the design, construction, maintenance and operation of electrical infrastructure and the electrical portions of Utility facilities on the OSU Main campus. Utilities UTHVS maintains a Planning and Design Guide that provides the technical basis for many of these requirements and should be consulted before recommending alternatives or any nonconformance.

48 03 01. Power Plant Busses

.1 INTRODUCTION: The primary objective of dividing plant boiler and chiller loads between the two primary feeds is to achieve some level of tolerance in the power plant to electrical system upsets. Major upsets originating with the external utility, AEP, will impact all boilers and chillers. The electrical system is equipped with emergency generation capacity to restart power plant boilers individually and re-establish critical steam loads, with the further objective of re-starting internal steam powered generation and re-establishing some critical electrical distribution circuits. For internal upsets, we seek to limit the potential impact to no more than half our steaming or cooling capacity. Grouping auxiliaries for each boiler or chiller facilitates switching during a power outage and limits the impact that an internal power outage will have on boiler and chiller operation.

.2 GENERAL CONSIDERATIONS: McCracken Power Plant electrical supplies are organized to limit the number of boilers and chillers impacted by the loss of any one bus or feeder. McCracken Power Plant receives power from three incoming feeds at 13.2 KV. These feeds are powered from OSU Sub and enter Smith Sub where they power Forced Draft (FD) fan Variable Frequency Drive’s (VFD) for Boilers 1, 3, 5, 6 and 7. Two feeders, 412 and 612, fed from Smith Sub, power the power plant 480 VAC system. Plant chiller loads are powered at 4160 VAC from Smith Sub 4160 V systems and from the plant 480 V systems. The bus arrangements at Smith Sub support two independent feeds to the plant; one orientated to bus 400, one to bus 600. These busses are in turn fed from bus 100 and bus 300 respectively at OSU Sub. Each of these two busses can be alternatively fed from bus 200 at OSU Sub through bus 500 at Smith Sub.

Bus 400 orientated busses and feeders are: 13.2 KV Bus 401, 13.2 KV Feeder 412, 13.2 / 4 KV Transformer T1400 (North), 4160 V Bus 1400, Chiller Bus 89, FD Fan bus 1401, Transformers T2 and T3, 480 V Sub 2 and 3, T5, 480 Sub 5, Smith Sub 480 V MCC 2.

Bus 600 orientated busses and feeders are: 13.2 KV Bus 601, 13.2 KV Feeder 612, 13.2 / 4 KV Transformer T1600 (North), 4160 V Bus 1600, Chiller Bus 67, FD Fan bus 1601, Transformers T1 and T4, 480 V Sub 1 and 4, Smith Sub 480 V MCC 4.

All boilers and chiller groups have an orientation to either Bus 400 or Bus 600. This orientation governs the choice of chiller power as well as the choice of power sources to their respective auxiliary equipment (fuel oil pumps, ID fans, boiler feed pumps, chilled and condenser water and associated control power). Where redundant auxiliaries have been provided, the power orientation of all redundant auxiliaries shall be the same.

.3 MEDIUM VOLTAGE DISTRIBUTION SYSTEM: The McCracken Power Plant 5 KV power distribution system is supplied from two 10 MVA 13.2 KV to 4160 Volt power transformers located at the McCracken Substation. Each of these transformers powers a 4160 V bus that in turn powers miscellaneous plant boiler fans and large pumps as well as the larger chiller package compressors. Both of these busses are equipped with 2300 KVA emergency diesel generators capable of supplying critical plant electrical loads.

.4 LOW VOLTAGE DISTRIBUTION SYSTEM: The McCracken Power Plant 480 V power distribution system is supplied from one single ended and two double-ended unit substations located within the power plant. One double-ended substation (unit subs 1 and 2) is located in the MCC room. The other double-ended substation (unit subs 3 and 4) is located on the mezzanine on the east wall of the power plant. The single ended substation (unit sub 5) is located in north eastern end of the basement. The McCracken LV distribution is a mix of solidly grounded and resistance grounded distributions. Sub 1, 2 and 5 are operated high resistance grounded with ground location. Sub 3 and 4 are solidly grounded 3 wire systems. There are plans to convert these to resistance grounding. Plant loads are 3 phase or connected phase to phase. Single phase to ground loads are not permitted. Running a loadable neutral wire along with phase leads is not a requirement of the distribution system design.

.5 NEW CENTRALIZED FACILITIES: New facilities and major additions to facilities that have built-in redundancies of equipment or functionality shall be designed with electrical distribution systems that support and mirror those redundancies. The most common power system redundancies are designed around two or three bus schemes and reflect how the energy supply to the facility is provided. Facilities fed directly from the main OSU or West Campus Substation buses can be designed around a maximum of three buses as is the case with the South Regional Chiller Water Plant. Facilities fed off the MV distribution system sharing primary distribution system circuits with other buildings and facilities will generally be designed around a two bus scheme to keep feeder loadings within system design criteria contingency loading limits as is the case with the East Regional Chilled Water Plant. Both the South central Chilled Water and East Regional Chilled Water facilities have their Low Voltage distributions rated 575 V resistance grounded. Both also have their chillers powered off 5 kV busses. The 5 kV systems at both locations are low resistance grounded as well to reduce fault induced equipment damage and Arc flash levels.

.6 STANDBY POWER GENERATION: Standby power sources provided for, or as an adjunct to OSU Utility Facilities, designed with the capability to be operated in parallel with the MV distribution system shall be provided with a means to automatically isolate from the system upon loss of external utility connection.

Normally a standby power system will be automatically started on loss of external utility power and support a limited portion of the MV distribution, typically MV distribution within a facility such as a central chiller plant or the McCracken power plant. In this mode, they are not operated in parallel to the outside utility except to transfer load back to the external utility once the normal source of external power is restored. It is quite common however to run periodic load tests with the standby power system connected to the external utility. This is done to avoid the cost of a load bank installation and to conserve energy. It is under such conditions that this requirement applies.

Separation may be accomplished by direct interlocking or it may be accomplished through a reliance on protectives applied to the standby generators. OSU Utilities has a standing commitment with the external utility (American Electric Power) to advise them of the presence of standby generation on the OSU MV distribution system and keep them appraised of any changes in capacity, interlocking or protection provided. Principal among concerns for what is generically termed “Distributed Generation” is the potential for it to back feed into the external utility grid and cause a concern for personnel safety and equipment damage.

There are two MV Standby Power systems allied to Utilities facilities on the Main Campus; one at Smith Substation for McCracken Plant and one situated northwest of McCracken that supports the South Regional Chilled Water Plant. As part of the McCracken power plant LV system there is a single independent DG set aligned to Sub 2 480 V distribution. Standby Power System loading at Smith and the Chiller support facility involves load shedding and manual load restoration.

48 03 02. Electrical Component Shielding

Solid state and microprocessor based components applied in mission critical functions in the Bulk Power System shall comply with accepted industry standards for emission and susceptibility to Radio Frequency Interference (RFI), magnetic fields, Electro-static Discharge (ESD), ultra violet radiation, temperature, humidity, chemical attack and vibration. Careful attention shall be paid to these aspects of the application of this class of equipment because this relatively sensitive equipment will be placed in service in or in close proximity to sources of adverse environments and high-energy fields. Proof of equipment compatibility and documentation of its compliance to industry standards will be required before final acceptance.

48 01 03. Wire and Cable

.1 COPPER CONDUCTORS: Copper conductors of 98 percent conductivity shall be used unless use is restricted by Government Agencies.

.2 COLOR CODING

Color coding for power wiring in McCracken Power Plant and allied facilities shall be as follows:

Phase	**Voltage**		
	4.16KV	575, 480Y/277	240/208/120
Neutral	White or Grey	White or Gray	White
	(Each with identifiable colored stripe)		
A	Brown	Brown	Black
B	Orange	Orange	Red
C	Yellow	Yellow	Blue
Equipment Ground	Green, Black or Bare	Green w/ Yellow stripe	Green

Control wiring at 125 DC, 120 AC are not generally color-coded in panels, nor is there a prescribed conductor color associated with the voltage or polarity when run in jacketed multi conductor color coded cable.

.3 MEDIUM VOLTAGE CABLE (5 KV)

5,000-volt service cables shall be UL Listed, 1/c, copper, 115 mil Ethylene propylene rubber insulated, 5 kV, 133% rated, shielded, MV 105° cables with low smoke (critical Temperature Index > 260°C) zero Halogen*. Tape Shield Cables shall have a 5 mil bare copper tape applied helically over the extruded insulation shield with an average minimum overlap of 25 percent of the tape width. The overall jacket shall be a continuous extruded, 80 mil polyolefin jacket which meets or exceeds the requirements of ICEA S-93-639 WC 74.

*Note: The zero-Halogen requirement may be waived by UTHVS for applications where halogen bearing cable jacket material poses little or no risk to personnel or equipment. OSU Utilities maintains a listing of approved cable suppliers and approved cable jacket constructions.

.4 GENERAL REQUIREMENTS FOR MEDIUM VOLTAGE CIRCUITS

.4.1 Circuits shall be rated to carry a minimum of 120% rated continuous load at a 60°C ambient. If an emergency rating is involved, the installation shall be designed to 120% of the emergency duty rating. The minimum size cable allowed for medium voltage feeder circuits is 4/0. Individual motor and load circuits can have reduced wire sized commensurate with the requirement of the NEC. All medium voltage circuits shall be shielded cable unless otherwise authorized in the design drawings and approved by UTHVS.

.4.2 Circuits shall be routed in bonded steel conduit with a diameter of 4 inches or greater as required by the choice of cable conductor and configuration. Use of aluminum conduit is not permitted. Tray installation of MV power cable is restricted to areas of the power plant substation where environmental effects are controlled, and physical protection can be assured. Power cable runs in tray shall conform to the NEC requirements for multiple conductor transposition, cooling, and shall have a 4/0 600 volt insulated ground conductor run for each set of three phase conductors in the circuit.

.4.3 Minimum bend radius considerations for the cable shall be observed at all times during installation and in the final installation and terminations.

.4.4 Oversized motor terminal boxes shall be specified to allow adequate termination space for motor leads to shielded cables

.4.5 Use of unshielded cable is restricted to locations where termination of shielded cable is not practical such as undersized motor terminal boxes. Use of unshielded cable must be approved in writing by UTHVS prior to installation. Such approval may be granted on a case by case basis for instances where the entire cable route is in rigid or flexible metallic conduit.

.4.6 Cable medium voltage terminations and splices shall be done with UTHVS approved Raychem Heat Shrink termination and splicing kits. All exposed energized surfaces on terminations shall be taped with UTHVS approved taping systems. Motor and equipment terminations to unshielded MV cable shall be taped or insulated with OSU Utility UTHVS approved taping systems or termination kits. All terminations shall be via bolted. Split bolts and pressure type fittings are not permitted. Cold shrink terminations are not approved. Certifications of the proposed installers shall be submitted to the University for review by the UTHVS personnel. All work performed on non-lead, medium voltage (1 kV to 35 kV) cables shall be performed by personnel with adequate training and experience and certified as qualified by the UTHVS. To be considered qualified for cable splicing, the individual’s employer must submit a resume with past training and experience supported by documentation of their having had the appropriate formal training in the preparation of relevant medium voltage splices and terminations, prior to the individual performing any work. Splicing and termination experience shall be recent (one to five years depending on extent of prior experience) and relevant to the type of splice and cables being spliced.

.4.7 Fire tape is applied to exposed cable for the purpose of protecting that cable from the failure of adjacent cables. For the purposes of this discussion, “exposed cable” refers to cable hung in air or run in ventilated tray. Cable in conduit requires taping only to the point where the cable enters and exits the conduit. Cable vaults and Manholes are areas commonly associated with the need to fire tape however the criteria governing taping is broader and may require taping in other areas of an industrial facility such as a power plant or central chiller facility. The application of fire tape serves two purposes. It limits the proximal damage caused by a cable failure and it reduces the probability that a cable failure will result in the loss of redundant circuits. This is true for instances where there is little risk of a general area fire caused by a large combustible inventory. Where an area fire is a serious concern, the recommended solution is to reroute critical cables and/or their redundant cables. The application of fire tape to cables in or out of trays offers some protection from an area fire of limited duration and intensity. Where there is little or no risk of an area or tray fire, adding barriers to trays containing redundant cables or placing redundant cables in separate trays is an acceptable design approach.

.5 LOW VOLTAGE CABLE (600 volt class): For Power, Control and Protection

NOTE: Some Utilities central facilities 480 VAC and 575 VAC sources are solidly grounded, but most are operated ungrounded. The choice of power source will materially affect the circuit protection design and may also affect the application of solid-state power switching equipment such as variable frequency drives. All protection and equipment designs shall accommodate the grounding condition for the power supply provided.

.5.1 Solid and stranded insulated conductor Wire: No.12 AWG and smaller may be solid. No. 10 and larger shall be stranded.

.5.2 Minimum size for all 125 VDC and 124/240 VAC branch circuits is No. 12 AWG.

.5.3 Minimum No. 14 AWG stranded for AC control wiring and auxiliary system circuits is permitted.

.5.4 Use of No. 12 AWG or greater for 125 VDC control wiring is required.

.5.5 Use of No 10 AWG for all current transformer circuit wiring is required.

.5.6 General Use insulation for 600 volt rated wire and cable shall be NEC, 600 volt class type XHHW2 with SIS allowed for power component internal control wiring. Jacketing shall be Low Smoke Zero Halogen. Nylon conductor jackets and the use of PVC for conductor insulation or jacketing are not acceptable for power plant, substations and associated facilities applications. All wiring between equipment, cabinets or control panels for low voltage power equipment power and control circuits shall be in conduit or tray. All control wiring between power components, cabinets and control panels shall be in jacketed color-coded tray cables bearing suitable durable cable identifiers. Panel and component wiring shall have individual wire labels. Acceptable labeling conventions include; destination labeling, unique wire numbering. Distribution panel branch circuits at 120 Vac and 125 Vdc, powering controls for electrical and I&C equipment are classified as control cable and run in color coded jacked multi conductor cable. Wire sizes AWG 8 and larger are exempted from this rule.

.5.7 ICEA Method 1 Table E2 convention shall be used to color code individual conductors of all jacketed multi-conductor cable. Equipment manufacturer supplied “special cables” are exempted from this requirement.

.5.8 All power cables are to be terminated in UTHVS approved solid, long barrel, plated lugs. Power cables carrying high current (greater than 50 Amps) are to have two or more bolts. Crimps are to be made by a crimp tool approved by the lug manufacturer following their approved procedures. All crimps shall be six point or more. A 360 deg crimp is preferred. In instances where the equipment taking the termination does not support two or more bolts, UTHVS shall be consulted and will determine the acceptability of the single bolt termination. Mechanical type connectors are not generally considered acceptable for power applications. Bolted connections shall be torque to appropriate levels.

48 03 04. Conduit and Fittings

.1 Conduit shall be rigid steel except as noted in section 48 03 05 below. EMT and Aluminum conduit are not permitted for control or power circuits except as noted in section 48 03 05 below. Galvanizing or corrosion protection is required when conduit will be placed in a known corrosive environment or where it will be exposed to moisture or the elements. Fiberglass conduit is permitted only in tunnels areas where wet conditions persist. It is not permitted for general use or in explosion hazard areas (Class I Div. II or more stringent).

.2 Conduit shall be sized for the number and gauge of the wire contained. The minimum conduit size allowed is 1 inch conduit. NEC requirements for conductor count and fill shall be followed for power cable except where specifically waived by UTHVS.

.3 Pull boxes shall be spaced at appropriate intervals to allow for pulling cable and not exceeding the manufacturers maximum pulling tension or side wall pressures.

.4 Cable minimum bend radius limits shall be observed for all cables during installation and in the final installed condition. “L” boxes shall not be used for shielded power cables, multi-conductor control or instrument cables with more than four conductors of AWG #14 wire or greater.

.5 Conduits and boxes shall be routed and installed clear of traffic areas, equipment access lay-down or removal areas, mechanical equipment subject to high temperatures, movement, or thermal displacement.

.6 Conduit shall be supported at regular intervals in both the vertical and horizontal directions.

.7 Multiple circuit power cables shall have all three phases and ground present in each conduit.

.8 All rigid steel conduit shall be provided with grounding bushings.

.9 Fittings shall be threaded, 2” diameter and below with insulated throats, 2.5” and above with grounding bushings. Compression connectors are permitted where use of threaded fittings is not practical subject to prior written approval by UTHVS. Set screw and die cast type couplings and connectors are not allowed.

48 03 05. Trays

.1 Trays may be used for power, control or instrument cable in areas known to be free from injurious chemical environments significant dirt or debris accumulation, physical, and explosion hazards. Construction of all trays shall be galvanized steel with limited exceptions for MV power cable trays

.2 Power trays shall be ventilated, expanded metal construction or ladder style. Multi-circuit power cables shall have their phase circuits transposed to avoid heating from circulating currents in the tray. In corrosive or damp environments or where dirt accumulation will be heavy, galvanized steel conduit shall be used. Aluminum ladder tray may be used to support MV cable.

.3 Control and Instrument trays may be ventilated or enclosed construction, solid metal construction is preferred. The tray shall be enclosed and covered in areas where dirt accumulation is anticipated. In corrosive, dirty or damp environments galvanized steel conduit should be used. Control and Instrument trays shall not contain AC power cables. Power cables are defined as cables supplying power to motor driven equipment, heaters, transformers etc. or power distribution panels where the loading of the cable may be substantial. Branch circuits serving only control loads with low to negligible circuit loading may exempted from this requirement.

125 VDC and 120/240 VAC control cables should not be placed in with instrument (analog or digital) signal cables if possible. If they do share tray they should be separated by a physical metallic barrier. Control and instrument cable may share tray or conduit for short runs (10 ft or less) when entering equipment or where cable access is limited.

.4 All trays shall be grounded. A continuous 4/0 stranded bare copper conductor shall be run the length of the tray, clamped or bonded to each tray section, and run to building ground directly or through building steel at intervals along the tray run not to exceed 100 lineal feet of tray. This ground cable shall be run external to the tray and not placed in the tray with the electrical cables.

.5 All trays shall be sized for the intended tray loading and supported at regular intervals to building structural elements. Supporting tray from equipment, ductwork, pipes or pipe hangers is not permitted.

48 03 06. Grounding

.1 GENERAL: Station grounding is provided for personnel protection, reduce equipment over-voltage exposure due to lightning, and to control stray voltage caused by static charges and electrical faults. Equipment case or enclosure grounding serves the same purpose. Grounding of major power components serves the purpose of conducting equipment fault currents safely away with very little increase in local contact potential.

McCracken Power Plant has been provided with a continuous ground bus that runs the perimeter of the basement elevation. This ground bus is tied to the Smith Sub grounding system at multiple points. As a preferred practice, all grounds should be run to this bus. An acceptable alternative, equipment and enclosure grounds can be run and bonded to adequately grounded, pre-existing equipment skids, or building steel so long as the maximum ground resistance limitation is observed (see section 1.02.03).

New Facilities shall be provided with a continuous ground bus that runs the perimeter of the basement elevation in the areas where power cable or equipment is located. This ground bus is tied to the building grounding system at multiple points. As a preferred practice, all grounds should be run to this bus. An acceptable alternative, equipment and enclosure grounds can be run and bonded to adequately grounded, pre-existing equipment skids or building steel so long as the maximum ground resistance limitation is observed (see section .2.2.3 below).

McCracken Power plant has been provided with an isolated instrument system ground bus distributed throughout the basement elevation that serves as a high-quality ground bus for control cabinet instrumentation system ground. This distributed ground bus is made up of 4/0 600 volt class insulated cable and is brought to ground at one point on the plant continuous perimeter ground bus. This is an instrument ground system and not intended for use to ground enclosures for safety purposes. Safety grounds and instrument grounds are to be kept isolated except where the two systems are joined at the perimeter ground connection.

New Facilities shall be provided with an isolated instrument system ground bus distributed throughout the building elevations that serves as a high-quality ground bus for control cabinet instrumentation system ground. This distributed ground bus should be made up of 4/0 600 volt class insulated cable and brought to ground at one point on the plant continuous perimeter ground bus. This is an instrument ground system and not intended for use to ground enclosures for safety purposes. Safety grounds and instrument grounds are to be kept isolated except where the two systems are joined at the perimeter ground connection.

.2 PRACTICES

.2.1 Grounding practices shall reflect IEEE Std. 142 Recommended Practices, and IEEE Std. 665 Guide for Generating Station Grounding.

.2.2 Grounding systems applied shall conform to applicable requirements of the National Electric Safety Code for medium voltage installations (15 and 5 KV) and the NEC for low voltage installations. Where NEC requirements conflict with this specification, this specification shall govern.

.2.3 All connections in the grounding system shall be clamped, exothermic welded, Cad Weld or equivalent. Individual grounding rods connected to the grounding system shall have a measured ground resistance of ten ohms (10 Ω) or less. This measurement may be made by any of the commonly accepted methods for measuring ground rod resistance to earth. Grounding for power equipment power circuit neutral grounding shall be no greater than one tenth ohm (0.1 Ω) measured from the neutral bus to the local ground bus or grounded building structural steel. Primary circuit (13.2 kV system) grounding shall conform to the NESC for potential rise during ground fault. Ground resistance shall be no greater than three ohms (3 Ω) for cabinet and control circuit grounds. Only copper to copper ground connections may be clamped or bolted. All other terminations shall be exothermally welded (Cadweld®ed).

.2.4 All medium voltage and low voltage power apparatus enclosures shall be grounded by two independent paths separately attached to a common ground bus or ground reference. Equipment skids and multiple equipment enclosure line-up shall have two independent 4/0 grounding points. For one of these ground points, individual cabinets and small enclosures (e.g. lighting transformers) can utilize the ground carried back to the supply panel with the power cable as long as this conductor carries no load current and is properly identified as a grounding conductor. Multiple groupings of enclosures can have their equipment grounds daisy chained and do not require that both ground paths be direct to building or station ground so long as the maximum ground resistance limitation is observed. Portions of equipment skid may require separate grounding accommodations where vibration eliminators, nonconductive expansion joints or galvanic protection (isolation points) have been installed. These applications must be referred to the Design authority, UTHVS or the equipment manufacturer to establish the proper grounding design.

.2.5 Design Drawings shall show ground systems, protective conduit sizes, and relative locations. Specifications and drawings shall include detailed requirements of the grounding system. Each design should have a detailed grounding plan that adequately describes the grounding requirements for the enclosure/skid and also the grounding requirements for major powered electrical components contained therein.

.2.6 Grounding systems shall at a minimum conform to applicable requirements of the National Electric Safety Code (NESC) for medium voltage installations (13.2 and 5 kV) and the NEC for low voltage installations. Where NEC requirements conflict with this Standard, this Standard shall govern.

.2.7 Where an existing ground bus system is provided, equipment grounds shall be brought to this system at the nearest point and attached via bolted connection or bonding (McCracken Power Plant basement elevation). Where a ground bus has not been installed, equipment grounds shall be brought to the nearest ground point which may be a ground cable, ground node or grounded building steel.

.2.8 A ground bus shall be provided in any room or area where electrical power equipment (switchgear, motors, transformers etc.) are congregated. The grounding bus shall be continuous and traverse the perimeter of the room or area. It shall be bonded to structural steel and any existing ground busses or grounding systems in the vicinity. The bus shall be fabricated out of minimum 4 X ¼ inch electrical grade copper bar stock. Ground bus joints shall be bolted in a 4 bolt pattern or brazed. If the area extends beyond the foundation line of the plant, ground rods shall be driven at 20 foot intervals (or at alternate grid intersection points along the perimeter and bonded to the ground bus using bare 4/0 solid or 4/0 7 stranded copper cable. Self-standing structures with a 10,000 square foot footprint or greater containing electrical power equipment shall be provided with a ground mat made up of bare 4/0 solid copper cable maximum10 foot spaced in a grid pattern with all joints bonded together and with 4/0 bare copper risers bonded to structure steel and brought above grade to the building ground bus at two or more independent locations, preferably at extreme opposite ends of the ground mat. Smaller structures and all structures with conductive walls or architectural features shall be provided with perimeter grounds bonded to the building ground system and attached via bare 4/0 copper ground cables to ground rods spaced a maximum of 20 foot apart along the perimeter.

.2.9 Grounding cable shall be bare 4/0 copper. Solid conductor 4/0 cable shall be used for buried installations, in locations subject to chemical attack or persistently damp conditions, and to ground permanent structures. Stranded 4/0 7 conductor) may be used with the written approval of UTHVS as an alternative. 4/0 19 strand cable is acceptable above grade for supported ground cable runs in or on trays or structures and where the ground cable is likely to need to be removed for equipment maintenance or replacement and corrosion is not expected to be a concern.

.2.10 Conductor and insulation when specified shall conform to the following requirements:

.10.1 4/0 bare solid conductor shall be used in applications where the conductor is placed below grade or in a corrosive environment.

.10.2 4/0 bare medium stranded (7 conductor) may be used in lieu of solid conductor in below grade applications and in mildly corrosive environments, and where conductor flexibility is a consideration.

.10.3 4/0 bare high stranding (up to 19 strands) is permitted in all above grade applications where exposure to corrosives is not a concern.

.10.4 All 4/0 bare copper ground cables shall be properly supported:

Solid:	supported at 4 foot maximum spacing
Medium stranding:	supported at 3 foot maximum spacing
High stranding:	supported at 2 foot maximum spacing

.10.5 Ground cables may be required to be insulated based on their use.

Transformer and generator neutrals connected to neutral resistors or reactors to limit ground fault currents must be insulated. Cable insulation shall be line-to-line voltage rated. Ground cables running from the Grounding resistor/reactor and station ground shall be bare 4/0 copper unless specified differently in the design.

.10.6 4/0 ground cables run in conduit or tray with feeder cables shall be insulated to avoid the possibility of arcing from stray ground currents during a power system ground fault. The insulation system required in this application is 600 volt class.

.10.7 All control panel and instrument cabinet instrument signal grounds (high quality grounding requirements) will be grounded to the nearest instrument grounding bus. In remote areas where instrument grounds do not exist, they must be installed by the contractor under the guidance of the Utilities High Voltage Shop.

.10.8 All remote electrical equipment, temporary service switches and outlets are to be grounded. Power panel branch circuits powering duplex outlets shall not be supplied through GFI or ACFI at the source but, if a GFI outlet is required, have the GFI local to or integral with the local service connection or outlet.

48 04 00 MISCELLANEOUS SYSTEMS

48 04 01. DC System

.1 The Plant DC system is rated 125 VDC and is operated ungrounded.

.2 The DC system must be supplied with ground detection and equipped to alarm off nominal voltage, ground, charger failure and loss of AC power to the charger.

.3 DC system protection shall be provided either by selectively applied Fuses or Circuit breakers. Protection is designed to isolate and eliminate faults. Battery and main distribution circuit fuses and breakers shall be sized to accommodate the short circuit duty of the system. The Battery shall power the DC system through a circuit breaker or fuse rated to ride through all DC system load faults, distribution system cabinet faults, and charger faults, and open only for a sustained fault condition on the battery leads and their connection to the distribution panels and chargers.

.4 DC system loads shall be restricted to loads required for the safe and reliable operation of the power system. This includes any circuits, loads or devices requiring uninterrupted power availability during facility AC transients or loss. Examples include switchgear control, some motor operated valves, critical instrument and control inverters and emergency lubricating oil systems.

.5 The normal source of power to DC loads shall be the battery charger, with the battery receiving a float charge. In critical applications the University may require redundant battery chargers aligned in a primary and backup configuration. Switching may be accomplished with a transfer switch (not preferred) or through the use of output isolation devices in each charger. An acceptable alternative to two permanently installed chargers is a crosstie to another battery system or a provision to attach a temporary charger.

.6 The battery is the principal source of DC power to the DC system. The system control, monitoring, and provisions for maintenance and protection shall reflect this.

.7 DC System loads shall not require a battery tap but shall be designed to operate at full battery voltage under normal and equalize voltage conditions. The use of low voltage control devices with series resistors is discouraged with the exception of indicating lamps that require series resistors for circuit reliability reasons.

.8 Surge or transient suppression schemes that can provide a short circuit path between battery positive and negative or from battery positive and negative to ground shall be fused.

.9 All circuit alarming and monitoring devices connected to the DC system shall be fused.

.10 Central DC system batteries shall be of the Substation type rechargeable wet cell design. They shall have a 20 year service life or better and be contained in transparent jars designed to facilitate the inspection of the battery internals. The Jar size (number of individual cells contained) shall be limited to what can be managed for replacement by two persons. The battery cells shall be housed in a suitably ventilated, lockable enclosure. The selection of battery technology shall appropriately reflect the service requirements and the ratings and limitations of the powered equipment.

48 04 02. Annunciators

.1 Local annunciators and remote annunciators shall be equipped with identical displays. All annunciators and remote annunciators shall be fully supervised, and annunciator systems shall be self-monitoring. The exact annunciator sequence for acknowledgement, test and reset will be determined by Utilities UTHVS for the specific design application.

.2 Annunciator power shall be supplied from the facility 125 VDC system. The annunciator system shall be designed to operate on a 125 VDC ungrounded system and be able to handle the transients common to such a system caused by the operation of electromechanical devices on that system and ambient radiated and conducted EMI emissions. Contact whetting may be off the 125 VDC system or an annunciator system generated source of voltage; 100 VDC or higher. The system shall be designed to recognize a contact closure or opening as the alarm condition.

Annunciation may signal critical system abnormal conditions such as failures and trips, conditions requiring prompt maintenance and conditions requiring routine maintenance follow-up or no immediate action (system status). The Annunciator system shall be designed to provide remote access to system and alarm point status as well as marshal alarm points into at least three categories of alarm for Utilities' use in dispatching personnel for follow-up.

Audible alarms shall be provided only if expressly required by UTHVS. Generally, audible alarming for facilities having a central or remote control station location is not desired because of the nuisance. The same is true for visual indication (strobe lights).

48 04 03. Lighting

.1 The lighting design shall provide for both task and access/egress lighting.

.2 Task lighting shall be at illumination levels appropriate for reading labels, metering, test instruments, and written instructions.

.3 Access/Egress lighting levels shall be adequate to ensure that personnel gaining access to and traversing or leaving plant areas can move safely and efficiently without concern for obstacles, tripping and bumping hazards.

48 05 00 WORK PRACTICES

All work performed in and for the McCracken Power Plant, central chiller and central steam generation facilities, and Allied Facilities shall be strictly controlled. These are operating facilities. As such, removal of equipment from service, starting, and operating equipment, connecting temporary loads, selection and assignment of power feeds, storage of construction materials, supplies, chemicals, and tools are under the control and at the discretion of Utility Management, Plant Operations, and Plant Maintenance staff.

All work shall be performed in accordance with approved drawings.

All work shall conform to the plant safety rules, processes and procedures. No work shall be commenced without the approval of the Power Plant management. Pre-job briefing of work crews is mandatory at the beginning of every shift. It is required that the contractor remains informed of the operating condition of the facility and provide continuous supervision of construction workers. Workspace cleanliness shall be observed at all times. Leaks and spills shall be contained and cleaned up promptly. Waste materials shall be placed in suitable containers and removed at the end of every shift or work period.

All workspace shall be returned to a clean and safe configuration at the end of the work shift or work period

48 05 01. Drawing System, Software and Firmware Control, Change Control, Labeling

.1 An engineered schematic design and vendor shop drawings must be submitted and approved by UTHVS before manufacturing and shipment is authorized. In addition, the University may also elect approval by inspection at manufacturer's plant before manufacturing and before shipment are authorized.

.2 Drawings submitted as “Construction” drawings shall be provided in reproducible but not alterable form for “record” as well as in native revisable format. The revisable format required for compatibility with the University CAD system is the current revision of AUTOCAD.

.3 Component and system software, firmware and configuration files shall also be provided in hard copy and or electronic media form as part of the “construction” package.

.4 Facilities Operations and Development and UTHVS require that complete and up to date schematic and point-to-point wiring diagrams and service manuals be furnished by the contractor as a part of his final submittal of Service and Instruction Manuals for the project. This information shall be prepared specifically for each component and system prior to construction and included in the project construction documentation (hardcopy and electronic).

.5 As the project progresses through the construction and commissioning process, an up to date marked up set of drawings shall be kept at site in a secure location under the control of the electrical contractor, prime contractor, or commissioning authority to serve as the Record Drawing Set for the project. Mark-ups to these drawings shall include all changes to the original design as well as a record of all changes and additions made to the design by construction contractor to accommodate interferences and as found conditions. These mark-ups shall be performed by qualified personnel, be complete and reflect good drafting practice. At the completion of the project, these marked up drawings shall be submitted to the original design entity for review and permanent incorporation onto project record drawings. These record drawings shall be provided within 60 days after (Temporary or Permanent/final) Certificate of Occupancy. At no time shall the university be without up to date marked-up drawings for the project. Usable and complete copies of project as-built’s shall be made prior to removing the original marked-up drawings from site and retained at site for use by the University engineering and maintenance personnel until the final record drawings can be issued and distributed for use.

.6 Facilities Operations and Development and UTHVS require that complete and up to date software and firmware, component configuration files, and source code where applicable be furnished by the contractor as a part of his final submittal for the project within 30 days of project completion. This information shall be prepared specifically for each programmable or configurable component and system included in the project.

.7 Labeling

.7.1 The Contractor, at the time of installation, shall label all major power components using terminology acceptable to UTHVS. Equipment labels shall provide the Name and function of the equipment as well as its power source. When the equipment is made up of two or more separately identifiable devices, sections, or compartments, these too shall be individually labeled. Nomenclature used on the labels shall be consistent with that used on the associated drawings, O&M documents and training materials. All labels identifying major equipment shall be readable from a distance of six feet. All labels providing instruction or used for the safe operation of major equipment shall be readable from a distance of three feet.

.7.2 Control devices such as control switches, relays, displays and instruments shown on One Lines, schematics, interconnection wiring diagrams etc. shall be labeled in nomenclature consistent with that used on the drawings.

.7.3 Labeling applied for the purposes of Operator safety, equipment protection and system operation considerations is Owner specified and may be applied by the Contractor based on contract documents (drawings or specifications) or may be applied upon construction completion by the Owner or the owner’s representative. Regardless, labeling shall be completed prior to release of equipment and systems to Utilities for operation. Refer to Utilities internal procedures for Arc Flash Hazard labeling standards.

48 05 02. General Material and Contractor Requirements

.1 The Contractor shall specify only Underwriter's Laboratories listed equipment, assemblies, and materials when such items are available and technically acceptable to the design. The equipment and materials shall be installed in accordance with its listing. Equipment and materials shall be selected from a pre-approved Vendor list when available, and subject to UTHVS approval.

.2 Contractors submitting proposals to provide electrical design or construction services shall be required to demonstrate adequate competency, and recent relevant work history. This requirement applies to the contractor’s supervision and work force as well as to subcontractors, their supervision and work force. Work experience, personnel credentials and work references shall be submitted in writing at the request of UTHVS for their review and approval. This requirement applies to all subcontractors as well. No electrical contractors shall be permitted to work on power plant or related facilities that have not established a verifiable record of quality of workmanship, safety and reliability.

48 06 00 SCHEDULES

48 06 01. Schedules (McCracken PP and Smith Sub)

The following orientations between power supply bus and electrically powered equipment shall be observed without exception. Control power and communication based control system power orientation shall reflect this orientation or be supplied from the Plant UPS.

.1 400 BUS ORIENTATION:

.1.1 Bus 400 orientated busses and feeders are:

- 13.2 KV Bus 401
- 13.2 KV Feeder to 480 Volt Unit Sub 2 and unit Sub 3 [T2, T3]
- 13.2 KV Feeder to 480 Volt Unit Sub 5 [T 5]
- 13.2 / 4 KV Transformer T1400 (North)
- 4160 V Bus 1400, Chiller Bus 89
- FD Fan bus 1401
- Smith Sub 480 V MCC. 2

.1.2 Bus 400 Associated Loads are:

- Boiler # 1
- Boiler # 3
- Boiler # 8 Future
- Chiller # 1
- Chiller # 2
- Chiller # 3
- Chiller # 5 Future
- Chiller # 8
- Chiller # 9
- Chiller # 10)

.2 600 BUS ORIENTATION:

.2.1 Bus 600 orientated busses and feeders are:

- 13.2 KV Bus 601
- 13.2 KV Feeder to 480 Volt Unit Sub 1 and unit Sub 4 [T1, T4]
- 13.2 / 4 KV Transformer T1600 (South)
- 4160 V Bus 1600, Chiller Bus 67
- FD Fan bus 1601
- Smith Sub 480 V MCC. 4

.2.2 Bus 600 Associated Loads are:

- Boiler # 5
- Boiler # 6
- Boiler # 7
- Chiller # 4
- Chiller # 6
- Chiller # 7

Bus and equipment power dependency schedules for Allied facilities and central Chiller Plants are unique to those facilities.

48 06 02. Schedules (South Campus Central Chiller Plant)

.1 BUS 100 C

5 kV Transformer 1100C
575 V Unit Sub 1A

575 V Unit Sub 3A (future)
Chiller # 1
Chiller # 2
Chiller # 3
Chiller # 4
Chiller # 7
Chiller # 8
Chiller # 9 (future)
Chiller # 10 (future)

.2 BUS 200 C

5 kV Transformer 1200C
575 V Unit Sub 1B
575 V Unit Sub 2A
Chiller # 1
Chiller # 2
Chiller # 5
Chiller # 6
Chiller # 7
Chiller # 8
Chiller # 11 (future)
Chiller # 12 (future)

.3 BUS 300 C

5 kV Transformer 1300C
575 V Unit Sub 2B
575 V Unit Sub 3B (future)
Chiller # 3
Chiller # 4
Chiller # 5
Chiller # 6
Chiller # 9 (future)
Chiller # 10 (future)
Chiller # 11 (future)
Chiller # 12 (future)

.4 Bus orientations for auxiliary components have their power orientation options aligned with the orientation options of the Chiller drives.

.5 Standby Power System alignment is to Bus 200C as is the Standby feed from West Campus Substation.

48 06 03. Schedules (East Regional Chilled Water Plant)

.1 PRIMARY SWITCH A (CKT 405)

5 kV Transformer TA powering Bus A
575 V Unit Sub Transformer T1A powering Bus 1A
Chiller # 1A
Chiller # 1B
Chiller # 2A
Chiller # 2B
Chiller # 3A
Chiller # 3B

Via 5 kV Tie

Chiller # 4A
Chiller # 4B
Chiller # 5A
Chiller # 5B
Chiller # 6A (Future)
Chiller # 6B (Future)

.2 PRIMARY SWITCH B (CKT 605)

5 kV Transformer TB powering Bus B
575 V Unit Sub Transformer T1B powering Bus 1B
Chiller # 4A
Chiller # 4B
Chiller # 5A
Chiller # 5B
Chiller # 6A (Future)
Chiller # 6B (Future)

Via 5 kV Tie

Chiller # 1A
Chiller # 1B
Chiller # 2A
Chiller # 2B
Chiller # 3A
Chiller # 3B

.3 Bus orientations for auxiliary components have their power orientation options aligned with the orientation options of the Chiller drives.

.4 A third feeder, CKT 505 is aligned to serve as back-up to Primary Switches A and B.

The assignment of motive power, control and instrumentation shall conform to the above described approach for all upgrades, expansions and modifications. Where facilities have UPS supplied busses for low voltage critical controls, critical feeds shall reflect the basic design approach given above for a division of power dependencies so as to avoid losing more than a portion of the powered equipment from a single power source failure. UPS Standby AC sources should be chosen to appropriately address the sustained loss of the UPS normal power, usually a battery/battery charger.

New construction designed to meet redundancy requirements shall have its major equipment motive power and control power dependencies defined and arranged at the Schematic Design stage to support those redundancy requirements.

48 08 00 TRAINING/TESTING AND COMMISSIONING

48 08 01. Training

.1 Operator training for routine operation of electrical systems or equipment shall be provided. Training requirements shall be set by the University on a case by case basis. Such training shall establish minimum training hours per shift, of on-site instruction for the daily operation of the system, to be attended by University’s designated Operations personnel. All training shall be scheduled by the contractor in coordination with the University’s Facilities Operations and

Development, Training Officer, and his designated representatives. Training sessions may be taped for future reference and training by the University.

.2 In addition to the warranty for labor and materials as specified in General Terms and Conditions: The vendor shall at the request of the University, provide additional technical on-site support for the system during warranty. All support shall be at the request of the University's Director of Utilities or designated representatives.

.3 The University desires to become self-sufficient and skilled to the point of being able to perform regular preventive maintenance, annual system inspections, remedial maintenance, and small renovations. In addition to the above Training for Operation, and Additional Support During Warranty, the design authority shall evaluate the following Training for System Maintenance categories and OEM manufacturer's standards and establish training expectations in the contract documents for:

.3.1 OEM hardware tools and documentation

.3.2 OEM software tools and documentation

.3.3 OEM training, at the University's FOD Training Center, on the use of the above hardware and software tools, and OEM certificate of "Authorized Warranty Service Technician" or equivalent. All training and diagnostics shall be identical to that as provided and available to the factory authorized service representatives. The training shall allow the University to perform all maintenance and inspection functions. The hardware tools shall include EEPROM programmers using industry standard IBM-compatible desktop PC's. The software tools shall perform on industry standard IBM-compatible desktop PC's, using industry standard MS-DOS or MS-Windows operating systems. The training shall be conducted by the manufacturer's trainers and shall include classroom hands-on training with instructor and travel. All Training for System Maintenance shall be coordinated with the University's FOD Training Officer and shall accommodate multiple shifts of maintenance personnel.

.3.4 The system, devices, and applications, along with OEM training of the University's Operations personnel, shall allow the University to perform the periodic inspection of the systems and equipment provided.

.3.5 UTHVS personnel may be assigned to commissioning, check-out and startup support roles for the express purpose of training and familiarization on systems and equipment.

48 08 02. Testing

.1 FACTORY TESTING: Factory testing for major equipment and integrated systems shall demonstrate design compliance to procurement and functional specifications. It shall be conducted to appropriate industry standards and include third party testing and verification. The option for Owner acceptance by participation in the testing or through a review of the testing results shall be made available with a minimum of two weeks written notice prior to planned commencement of testing.

.2 INSTALLATION QC TESTING: The contractor shall supply appropriate technically competent support personnel to monitor workmanship and completeness. This shall involve in-line work inspection or audit inspection with rigorous corrective action, follow up and closure on non-conforming work products and methods. Tests and inspections shall include OSU Standards compliance and compliance to good industry practices. Instrument calibration and set-point verification shall be included in the contractor's test and inspection planning and execution.

The contractor shall supply appropriate technically competent support personnel to test and inspect installations for fitness for service in accordance with Building Design Standards and NETA guidelines.

Testing shall be performed to demonstrate fitness for service of all components. A representative from the Utilities High Voltage Shop (UTHVS) shall witness the testing. Copies of test results shall be provided to FOD through Project Captain.

.3 POST INSTALLATION TESTING: The contractor shall supply appropriate technically competent support personnel to conduct and support a thorough pre-operational testing of all installed systems and components for all modes of operation in accordance with Building Design Standards and NETA guidelines. Testing shall include equipment controls, protective relays and safety interlocks.

.4 SYSTEM FUNCTIONAL TESTING: All systems shall be tested to demonstrate their ability to function as required over the full limits of their normal operational range and for any emergency range as called for in the system design. This testing shall be conducted with the systems and associated equipment installed and operating in their normal mounted orientation, settings and conditions of power supply and environment. This testing may be conducted in an integrated fashion with all system interfaced as designed or may be done piecemeal (overlapping) in a manner that demonstrates acceptable functionality of all interfaces, shared functions and dependencies.

.5 INTERLOCK VERIFICATION TESTING: Once all construction has been completed and all system installation and construction testing completed, the FOD or their appointed agent shall conduct testing designed to validate the proper operation of all system permissive, trips, critical sequences, operator HMI functions and annunciations. An independent testing Service (ITS) may be contracted to work in conjunction with the equipment suppliers' representatives to check out and startup LV switchgear, systems and equipment. A Relay Check-out Organization (RCO), working under direct engineering level supervision is generally required to perform checkout and startup of MV switchgear, systems and equipment.

.6 CERTIFICATION PROCESS: The Owner requires all test reports and records as well as individual certifications of any and all test authorities, the manufacturer or independent testing agencies be provided for review and acceptance. These records along with supporting documents showing acceptable resolution of open items, test discrepancies, failures and repair, retesting etc. will serve as the basis for certifying equipment for service by the Owner.

.7 ACCEPTANCE PROCESS: OSU Utilities, as the recognized authority having jurisdiction (AHJ) for Utility Plant equipment and distribution systems and facilities shall inspect for safe and conformant operation. The inspection shall follow due process and demonstrate due diligence in the review and acceptance of all installations and processes relating to quality, completeness and conformance to applicable Codes and Standards. Acceptance will be granted only after the inspection process has been completed to the AHJ's satisfaction and all documentation has been received, reviewed and accepted.

In the case of nonutility facilities, it is the standing protocol for OSU Utilities to defer to the ODIC for all low voltage inspections. The placement of the ODIC inspection sticker on low voltage switchgear is a requirement for primary service energization and Utilities relies on a successful completion of this inspection as Utilities performs only a cursory "housekeeping" inspection of the low voltage gear and verifies conformance to the BDS DIV 33 requirements that pertain to that main switchgear.

In the case of all Utility Facilities where Utilities is the AHJ, all inspections for both medium and low voltage systems are the responsibility of Utilities. On large projects, this inspection may be conducted for Utilities by an Independent Testing Agent. As noted above, these low voltage designs are not required to conform to the NEC. Hence the placement of an ODIC inspection sticker is not prerequisite to switchgear energization. However, UTHVS will in most cases require the ODIC inspection be present before the equipment is energized. This is to avoid contractor confusion and recognize the participation of ODIC.

Portions of the low voltage installation do however generally conform to the NEC. These portions are typically installations such as 120/208 systems for lighting and the like which are installed to the design documents but use industry installation practices administered by the electrical contractor and QC'd by that organization. From time to time, as a courtesy to OSU, the ODIC inspectors will perform an inspection of these installations and provide an inspection sticker to document that inspection. This sticker is not considered by Utilities to be an inspection based on the University BDS. OSU Utilities relies on the successful completion of the appropriate portions of the electrical checkout out and testing program conducted by Utilities staff and/or the Independent Testing Agent for their release to energize electrical distribution systems and equipment.

.7.1 Tests must be conducted in accordance with University requirements and shall be witnessed by representative(s) of UTHVS

.7.2 Medium and low voltage cable testing shall comply with NETA and AEIC guidelines with the following exceptions:

Hi-pot testing on 133% EPR insulated 13,200 volt system cable shall be a 42,000 volt DC High Pot performed by an approved test instrument witnessed by the UTHVS. The 42,000 volt High Pot test is applied in 7,000 volt intervals of one Min. duration with a 5 minute sustained interval at 42,000 volts. High Pot testing of existing installed primary cables is limited under normal conditions to 10,000 volts This 10,000 volt DC High Pot is applied gradually with a sustained duration at 10,000 volts for five minutes. The 42,000 test shall only be done after pulling, termination and splicing of new cables, but before splicing to the existing cables. A maximum of 10,000 volts dc high pot test shall be applied for all installations after splicing to existing cable.

Hi-pot testing on shielded 133% EPR insulated 4160 volt system cable shall be a 28,000 volt DC High Pot performed by an approved test instrument witnessed by the UTHVS Utility High Voltage Shop. The 28,000 volt High Pot test is applied in 7,000 volt intervals of one Min. duration with a 5 minute sustained interval at 28,000 volts. High Pot testing of existing installed primary cables is limited under normal conditions to 19,000 volts This 19,000 volt DC High Pot is applied gradually with a sustained duration at 19,000 volts for five minutes. The above limits apply to cables without the presence of a surge suppressor.

Hi-pot testing for 600 volt circuits may be elevated to a maximum 2500 VDC 1 minute duration for certain critical control components as identified by Utility High Voltage Services on a case by case basis.

.7.3 Commissioning Plan: The engineer, or commissioning agent, will provide a commissioning plan for all systems and associated devices. The Commissioning plan will include a detailed checklist to commission each item installed by the project. Each item will be commissioned by qualified professionals and factory trained personnel. Each device along with its electrical and process field connections will be field verified end to end. Each item shall be functionally tested to demonstrate the installation meets the design's technical and operational requirements to the satisfaction of The University, Utilities Department.

.7.4 Field calibration records: All transmitters and positioners will be field calibrated by personnel trained in field calibrations. Each calibration will be documented on a calibration sheet. Calibration sheets will have as a minimum: Tag Name, Description, Location, Process variable, Range, Calibrator type and model with last date of certified calibration, and calibration data showing As-Found and As-Left checks. Instrument calibration checks will be 0-25-50-75-100 percent of range recorded on the calibration sheet.

All Protective relays will be field calibrated by personnel trained in field calibrations. Each calibration will be documented on a calibration sheet. Calibration sheets will have as a minimum: Tag Name, Description, Location, and recorded on the calibration sheet.

48 09 00 INSTRUMENTATION & CONTROL FOR MAJOR ELECTRICAL PLANT EQUIPMENT

Note: Refer to 40 90 00 for requirements relating specifically to Process Control and monitoring for fluid systems and components.

48 09 10. Design Requirements for Instrumentation and Control for Power Plant and Auxiliary Equipment

.1 GENERAL: This section addresses the control of major substation and distribution system electrical equipment such as switchgear, large power transformers and auxiliary support systems and equipment such as station battery systems, automatic transfer controls medium and low voltage motor control centers and transfer switches. The requirements contained in this section are to be used in conjunction with the requirements of other BDS DIV 40 and 48 sections giving detail requirements relating to specific equipment and systems and their wiring and physical installation. Included in this section are requirements for controls using solid state and electromechanical relays, programmable logic controllers, motor starters, transfer switches, medium and low voltage switchgear, custom manufactured package systems, 125 v DC systems, power transformers of all sizes.

This section addresses the principal design criteria for the control of this equipment. The instrumentation referred to in this section is the power instrumentation required for the operation, testing and maintenance of this equipment such as ammeters, voltmeters, indicator lights, current transformers, potential transformers, shunts, meters, data acquisition systems etc.

.2 OPERABILITY: Controls shall be designed to address the range of normal and emergency service requirements relating to the equipment and systems being controlled. If controls are limited to manually initiated control functions, they should conform closely to conventions and practices widely used elsewhere for similar systems and equipment. Instrumentation needs to be present (at or near the control station location) to assist the operator in determining the effectiveness of the control actions taken. If the controls are automatic, they should contain features that provide status on the controls, the process and or parameters being controlled. These features should not depend on the same instruments providing the control variable inputs to the automation. Where automation has been applied to supplant manual control, the capability of some basic level of manual override should be provided along with the means for the operator to assess the situation and receive feedback on any manual operations undertaken (example: an E stop with indication, a speed control pot with speed indication).

.3 MAINTAINABILITY: Controls should be designed to facilitate planned maintenance for the systems and equipment being controlled. An example of this would be the inclusion of a manual control station to facilitate draining or filling operations or system post maintenance startup. Automatic controls should be provided with information relating to the availability of system equipment when it has been removed from service for maintenance. LOTO considerations relating to local power disconnects, power source lock-out, etc. must be accommodated.

.4 CONSTRUCTABILITY: Controls must be designed in conformance with the physical constraints of the facility. Control stations, cabinets, panels and compartments must be designed to facilitate cable access and provide adequate areas for orderly field cable marshaling and termination. Since the standards require the use of multi-conductor color coded jacketed and labeled cables with wire sizes in the AWG 10 to 14 for control conductors and AWG 16 for some instrumentation cables, cable management requires careful planning and design.

.5 TESTABILITY: Controls need to be designed to facilitate planned preoperational and post maintenance testing for the systems and equipment being controlled. This may mean designing the controls with built in test modes of operation, or it may simply involve designing the controls to facilitate LOTO depending on system complexity and the various types of testing to be accommodated.

Automatic controls should be provided with information relating to the availability of system equipment when it has been removed from service for maintenance and testing.

.6 HUMAN FACTORS

.6.1 Accessibility: Control stations need to be located where they can be conveniently reached and where they will not be in the way of routine or planned maintenance. Mounting control stations on equipment or in areas where access cold be restricted because of ambient noise, high temperature or a higher than normal risk of steam or water leaks should be avoided.

.6.2 Lighting: Control stations need to have lighting adequate to support the operator actions planned as well as sufficient access and egress lighting. Where task lighting cannot be supplied at high enough levels to accommodate operator needs, displays should be designed with back lighting or the control station should have its own source of task illumination.

.7 HUMAN MACHINE INTERFACE (HMI)

.7.1 Type: The HMI selected should be appropriate to the task being performed. Hard wired controls for simple control actions, touch screens for more complex tasks, and where a visuals or process displays would be helpful, analog displays for displaying rapidly changing parameters, digital where slow moving parameters are involved, where there is a wide range in the variable, or where precision is needed.

.7.2 Information displayed: The information displayed at a control station should be compatible with and adequate for the control actions planned for the station. Information displayed should be organized in a logical manner in relation to the control devices. Clutter should be avoided.

.7.3 Controls available: Control devices available at a control station should be limited to what is required for the intended operations. Main or frequently used controls should be located centrally within the easiest reach of the operator. Less frequently used control should be positioned in their own functional grouping, out of the central control area. Some controls that are not intended for normal control operations such as E-stops, or devices that would cause serious disruption if inadvertently operated should be placed in an accessible location but away from the more frequented areas of the control station. Functional grouping of controls is preferred. Clutter should be avoided. Guards should be provided or the “two independent action” rule should be employed where inadvertent operation could have grave repercussions.

.8 ENVIRONMENT

.8.1 Temperature, Humidity: Apply control components and locate control stations where they will not be exposed to adverse ambient temperatures, humidity and dew point cycling if at all possible. Enclosures should be designed with cabinet heaters for high humidity environments and should have a NEMA enclosure design consistent with the environment.

.8.2 Water hazards: Where water hazards could exist, control station equipment should be watertight or resistant. Care must be taken to ensure that cable access is from below or low to the side. Where moisture intrusion is considered a risk, the control cabinet should be equipped with a bottom drain point that is screened to exclude insects and rodents.

.8.3 Proximate hazards: Locate control stations only where there is minimal risk of exposure to proximal hazards such as steam leaks, rupture diaphragms, safety valves, electrical Arc Flash, falling or tripping. Access to control stations should not involve climbing or the use of any temporary structures, ladders or scaffolding.

.9 FAILURE MODES AND EFFECTS ANALYSIS

.9.1 Design practices: The Design shall include a formal control plan that identifies and addresses all the key design features that define or impact on the design of the control system.

Discussion of intended operation:

- Automatic features
- Manual features
- HMI types and locations
- Design features
- Power Dependency
- Failure modes
- Tripping
- Interlocking
- Alarming

The design of the controls should observe to the extent practicable established and standardized control practices so as to benefit from past experience and lessons learned. The application of control components should be standardized around a limited set of approved components and manufacturer product lines to simplify spare parts stocking and training. Control circuit designs should be replicate between similar pieces of electrical power equipment and between similar systems.

.9.2 Failure modes

Control circuit failure modes should be identified and evaluated. Predominant failure modes should be accommodated by designing adequate annunciation and or indication to assure that the operator is aware of the failure and can take appropriate operator action. The impact of individual component failures should be minimized by applying the component in a manner so that the dominant failure mechanism would have the least significant impact on the system operation or potential for equipment damage.

Power dependencies should be identified and evaluated. Power sources should be selected to conform to the overall power dependencies of the prime movers in the system. The choice of control voltage should be based on the characteristics of the control power sources available.

Battery backed 125 vdc is the most reliable source but designs powered from battery backed 125 vdc should be energize to actuate, normally de-energized and be capable of being de-energized with critical systems in operation without the controlled system tripping. 125 vdc is the preferred source for electromechanical controls that must operate under blackout conditions and when system ac power is lost.

120 vac inverter backed control is the preferred power for ac powered electronic controls and instrumentation that must remain in service independent of the availability of system ac power. Inverter use should be restricted to this type of load and under no condition should an inverted backed ac source power motors or load with significant startup transients with the possible exception of switching type power supplies. Inverter sources are inherently current limiting, so the exposure of these circuits to shorts or grounds is a concern. This concern can be mitigated somewhat by providing a solid state transfer switch to an alternate source of ac with greater fault support capacity, and the appropriate selection of inverter output distribution panel circuit breakers. If electromechanical control devices such as relays and solenoids are powered off an inverter backed source, coil suppression is recommended.

Diesel backed ac is the preferred source for controls that can sustain a momentary or short term loss of ac power and still function acceptably once power is restored. In the case of Emergency Diesel Generator power, restoration usually occurs in around ten (10) seconds. In the case of Standby generators, restoration may take as long as a minute or more.

.9.3 System effects

The system effects of a control system or component failure need to be assessed and addressed in the control design. Control failure modes must be compatible with system and component preferred failure states. A fail closed air operated valve will generally require a solenoid and control circuit design where a solenoid coil or control power failure will result in the valve closure as well. A circuit breaker control which is designed to open and close the breaker is generally designed to fail as is. Safety considerations are another factor to be considered in control design. A failure in the trip circuit of a circuit breaker should remove power to both the close and trip portions of the breaker control circuits. This is a useful safety feature to avoid the possibility of closing a breaker whose trip circuit has already failed. Likewise, powering the closed indication of a circuit breaker by having the closed indicator light powered from the trip circuit through the trip coil of the breaker insures that the loss of closed indication on breaker closing will alert the operator to a possible abnormal situation with the breaker.

Note:
Charging power for an electrically charged circuit breaker should never be drawn from the trip circuit of the breaker if the charging motor is designed to go through its charging cycle after the breaker closes. This introduces a failure mode that would in effect be the equivalent of closing a CB with a failed trip circuit.

.9.4 Situational awareness

Particular care must be taken to insure that the instrumentation provided with controls provides adequate situational awareness for the operator to assess the effectiveness of automatic controls and to monitor manual control actions. Instruments and displays provided for monitoring the condition of the controlled system generally should not share signals with the instruments controlling the system. As a general rule instrumentation that the automatic control function relies upon for its control action should be independent of the instrumentation relied upon to determine effectiveness of the automatic controls or depended upon to take manual control action.

.9.5 Recovery and use of lower tier controls

It is customary to provide echelon control to complex systems. Echelon control involves applying controls in layers. A system may have a master control that provides system level commands from a system operator or automatic dispatch control. This Master control may control only that one system or a variety of systems to coordinate their individual automatic operations. A system then may have subsystems that have their own automation and so on. Each of these layers may have both automatic and manual control modes.

As a general rule, a system or group of systems that share an echelon control architecture should have their controls designed to allow higher echelon automation to automatically detect the loss of lower echelon automation and take appropriate compensatory action to address system control needs including operator situational awareness and appropriate adjustment of lower tier operating modes, set points and limits.

Echelon controls should not be applied where loss of a subsystem's automation will result in a wholesale loss of system automation and wholesale reversion to manual control. Loss of automatic control at any level should always be readily recoverable by skilled operator action or result in placing the subsystem in a safe condition or operational mode with minimum disruption to the remainder of the control system.

48 09 20. General Requirements for Control and Instrumentation Circuits and Enclosures

Note: Refer to 40 90 00 for requirements relating specifically to Process Control and monitoring for fluid systems and components.

.1 AC and DC control circuits shall not be run in the same control cable. Low level instrument cables shall not be run in conduit or in tray shared by power, or 110 vac, 125 vdc control cables.

.2 All control panel, control cabinet and switchgear wiring No. 10 AWG and smaller shall be landed on OSU Utility approved terminal blocks. Stranded wire termination shall be with approved ring type solid un-insulated barrel design. No more than two wires shall be terminated on any screw type terminal point. Thread on wire nuts or split bolt connectors are not permitted. In-line control wire splices are not acceptable for new installations.

.3 Control cable butt splicing for modifications or upgrades is permitted with prior approval of UTHVS. Butt splices in control and instrument cable conductors shall be made with the appropriate sized butt connectors and insulated with electrical tape or approved heat shrink tubing with appropriate shimming.

.4 All control components are to be secured firmly to their supporting structures. Self-adhesive fasteners and thermo plastic fasteners are not acceptable.

.5 All cables and wiring that is field run to control panels or equipment enclosures shall be terminated on UTHVS approved terminal blocks. In general, termination of jacketed multi-conductor color coded cables #14 AWG and larger directly onto high density terminal blocks or termination modules is not acceptable.

Landing field wires directly on serviceable components is not permitted. Small local control stations may be excluded from this requirement. Termination of stranded wire to high density terminal blocks or terminal blocks that employ pressure type terminal clamping shall be via ferule. In instances where the use of ferrules is not practical, the wires are to be stripped to allow enough exposed conductor to permit full penetration into the terminal and tinned to form a solid conductor. Terminations made to terminal blocks that employ a pressure type terminal shall have conductor insulation extend up to the block and not show exposed conductor. High density screw type terminations, where permitted, shall employ insulated lugs where necessary to maintain adequate electrical clearance between adjacent terminations

.6 All current transformer secondary circuits shall be wired through shorting type terminal blocks.

.7 All control cabinet and enclosure control wiring shall be dressed neatly, bundled and laced. Heavy duty UV resistant tie-wraps are an acceptable method of lacing. Panduit may be used to organize and support control wiring in high density applications where expressly approved by UTHVS. No field cables shall be run along with cabinet wiring in Panduit and field cable jackets shall not be stripped back and the conductors run with cabinet wiring in Panduit. Cable and wire bundles shall be supported at regular intervals. Generally lacing to cabinet mounted tie points is an acceptable approach. Self-adhesive tie-downs are not acceptable. All control cable bundles shall be routed away from power circuits, crossing only at right angles.

.8 Every reasonable effort shall be made to separate 480 and 575 V equipment and circuits from control wiring. 480 V components and wiring shall be mounted separate from control components and provided separate access. Control components accessed for operations or maintenance shall not share the same enclosure with the power switching components or exposed power wiring without adequate protection from accidental contact by personnel or tools.

.9 In instances where low voltage (125 volts or less) control components and wiring must be housed in a common enclosure with power circuits (220 volts or above), exposed power circuit conductor surfaces shall be provided with a barrier to reduce the likelihood of accidental shock or burn.

.10 The preferred configuration for the separation of power and control is to have the power cabinet separate and to the side of the control cabinet. If this is not possible, the power cabinet and components should be mounted above rather than below the control cabinet or panel. Points of interface between control and power circuits such as control transformers shall be located with the power equipment. Secondary (control) fuses shall be located in the control area, not on the control transformer or in the power area.

.11 Adequate consideration shall be given to the operating temperature environment for temperature sensitive components. Electronics shall be mounted below the mid-plane of their housing enclosure. Sources of heat generation such as transformers and power supplies shall be mounted above, not under temperature sensitive equipment and enclosures shall be sized to operate closed without forced ventilation or the need for fans or filters. A maximum of 10° C temperature rise is allowed on enclosures for equipment rated 60° C or less. This shall be verified by heat run test or analysis and the rise shall be measured at the top of the enclosure.

.12 All control cables entering control cabinets and enclosures shall be secured by their jackets to a cabinet or enclosure support to provide a strain relief for the cable wire terminations. Field cables entering a cabinet shall not be bundled so as to obscure cable identifying labels. Cable identification labels shall be visible without removing equipment or disturbing the cable.

.13 Control wiring traversing hinges or other forms of flexible constructions shall be high-stranded and shall traverse the area of bending normal to the plane of rotation so as to impart a twisting rather than a bending motion to the cable or wire bundle.

.14 GENERAL WIRING REQUIREMENTS for Control Circuits
(See section 48 03 03)

.15 INSTRUMENTATION WIRING (300 volt class and below)

.15.1 Use of No. 16 AWG XHHW2 for all analog instrument circuit wiring (<50 V) is required.

.15.2 Use of manufacturers approved plenum rated cable for all communications and digitally based signal cables is required.

48 11 00 GENERATION (BULK, PEAKING, AND STANDBY)
(Reserved for future generating capacity additions)

48 19 00 POWER PLANT ELECTRICAL EQUIPMENT
(Reserved for Equipment Application Specifications)

48 19 01. Fusing and protective Devices (future)

48 19 02. Generic Specifications (future)

.1 MOTORS

.2 TRANSFORMERS

.3 SWITCHGEAR

.4 DISTRIBUTION PANELS

.5 VFDs

.6 SOFT STARTERS

.7 MV MCCs

.8 IINVERTERS

.9 CONTROL PANELS

.10 MOTOR CONTROL CENTERS AND LV STARTERS

Note: While this section of DIV 48 remains a work in progress, UTHVS maintains a supplemental Planning and Design Guide. This guide contains engineering guidance relevant to the above equipment design and application.

48 19 03. Models and Studies

The University (UTHVS) maintains current fault, coordination and Arc Fault studies for Main substations, the MV distribution System and all central facilities. These models and studies are available to Engineers performing work on the MV system and any of the Utility operated and maintained facilities. Any Engineered changes to these facilities or the MV system of sufficient scope to impact any of these models or studies will require the studies or models be updated by the Engineer. Models are kept current on a periodic basis by UTHVS and are updated as needed for small changes by UTHVS.