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Standards

HLMI-STD-ENG-50510

Electrical Installations

Revision 0, Change 2

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Change Summary

Description of Change

Update references and/or forms that were changed during de-bluesheeting.

TABLE OF CONTENTS

1.0 INTRODUCTION

This standard establishes requirements for design and acceptance criteria for new facility electrical installations, and additions or modifications to existing facilities.

This standard shall apply to all permanent and temporary facility electrical systems, structures, components, materials and equipment, both fixed and portable, on the facility side of the electrical utility point of supply, or connected to a generator, battery, or other electrical energy source using permanent wiring methods. It shall apply to cord and plug connected equipment of custom design or shop fabrication.

This standard shall not apply to mass production factory assembled electrical equipment connected to electrical source only through cord and plug. It shall not apply to hand-held devices regarded by U.S. Department of Energy (DOE) as “personal property” that is either cord and plug connected or powered by electrical battery alone.

This standard details Hanford Laboratory Management and Integration, LLC (HLMI) requirements for integrating numerous overlapping contractual, regulatory, and legal requirements for electrical installations – National Fire Protection Association, Washington Administrative Code, Occupational Safety and Health Administration, Hanford Site Electrical Safety Program. The detail provided in this standard shall not be used to dismiss applicable ASME NQA-1 requirements.

2.0 IMPLEMENTATION

Each revision of this standard is effective on the date shown in the page 1 header for release of that revision. It applies only to new designs, additions, and modifications started after the release of the revision.

Requirements in this standard are identified by “shall” statements. Good practices or guidance are identified by “should” statements. These good practices should be considered on a case-by-case basis by the design authority for new designs or major modifications, based on practicality of implementation and benefit gained.

This standard identifies required:

- Electrical Design Standards
- Technical Documentation
- Minimum Characteristics of Materials and Equipment
- Material and Equipment Safety Evaluation and Testing.

3.0 STANDARD

3.1 General

This standard consolidates HLMI contractual requirements for electrical equipment safety evaluation and testing, and electrical design documentation and verification, as required by Occupational Safety and Health Administration (OSHA), Washington Administrative Code (WAC), DOE Hanford Site Electrical Safety Program, OSHA recognized standards of qualified testing laboratories, WAC qualification of field evaluation Laboratories and Engineers, American National Standards Institute (ANSI) standards for electrical product safety evaluation and testing, American Society of Mechanical Engineers (ASME) NQA-1 design verification, and electrical requirements of National Fire Protection Association (NFPA) 70®, National Electric Code®, NFPA 790, *Standard for Competency of Third-Party Field Evaluation Bodies* and NFPA 791, *Recommended Practice and Procedures for Unlabeled Electrical Equipment Evaluation*.

This standard also identifies requirements originating with HLMI established operations and engineering authorities as best practice in safe economics of HLMI facilities.

3.2 Design Verification, Electrical Loads

The documentation requirements of Section 3.2.1~~3.2.1~~ shall apply to all new installations and all modifications of existing installations. For modifications, missing documentation shall be created, and incomplete or inaccurate documentation shall be corrected.

3.2.1 Design Documentation, Electrical Distribution

Electrical loads and demand factors shall be documented sufficient to meet National Electrical Code® (NFPA 70®) requirements for proper sizing of electrical distribution equipment and circuits. Only demand factors listed in National Electrical Code (NEC) shall be used.

If appropriate distribution equipment ratings and feeder circuit sizes are not apparent to a qualified electrical engineer during design verification from the documented loads and factors including tabulations embedded in panelboard schedules and other drawings, then an explicit calculation shall be documented, sufficient to support verification of feeder circuit ampacities.

For consistency with best industry practices as implemented by Washington State Standards for electrical plan reviews, and compliance with 2017 edition of NEC Article 215.5, *Diagrams of Feeders* electrical loads and demand factors shall be identified on panelboard schedules (in units of Volt-Ampere [VA]) and single-line diagrams (in units native to the load).

Demand loads measured in accordance with NEC Article 220.87, *Load Studies* shall be identified and documented. The source data file and results shall be referenced in the panelboard schedule or calculation.

Ampere or kVA ratings for distribution equipment shall be identified on panelboard schedules and single-line diagrams. Feeder conductor sizes, insulation systems and protection systems shall be identified on electrical plans and feeder schedules, as applicable.

Conversion of previously documented loads from units of Watts and Horsepower to kVA or VA and Amps shall include the best available information about the connected load.

The following guidance should be used in making conversions:

- For motors, kW may be converted to HP at 0.746 kW/HP, then to Amperage using NEC Tables 430.248, 430.249, 430.250
- For lighting ballast, the manufacturers stated efficiency and power factor may be essential for converting Watts to VA unless Amperage is published
- For resistive heating and lighting, Watts and VA have the same value
- For most electronic loads having switching power supplies, appliances including computers, Programmable Logic Controllers, displays, printing, instruments, analyzers, control system power supplies, and other electronic systems, power factors can be very poor. Rated Amperage should be published in manufacturer's specifications. Otherwise, a conservative estimate may be based on reviewing published data for similar units on the market that are less efficient and have smaller power factors than average.

3.3 Design Acceptance Criteria

The requirements of Section 3.3.1~~3.3.1~~ shall be applied to applicable design documents and incorporated in applicable statements of work.

3.3.1 National Electrical Code Inspection Approval

Electrical design shall comply with NFPA 70®, NEC, whichever edition is currently adopted by WAC, and shall comply with WAC. All electrical equipment and wiring installed or used on the Hanford Site, including temporary installations, shall be subject to HLMI-PRO-ENG-50728, *NEC Compliance Inspection*, for an Electrical Installation Permit, and for inspection and approval by a HLMI qualified NEC Inspector.

Electrical designs shall be based on equipment that is listed and labeled by the manufacturer (see definitions, Section 4.0~~4.0~~). When functional requirements cannot be met using listed and labeled equipment, electrical designs shall specify equipment conforming to an ANSI standard for product safety, field evaluation and testing, if possible. Only as last resort shall equipment be specified which conforms to no ANSI standard for product safety.

3.3.1.1 Electrical Equipment Listing and Labeling

Electrical equipment specifications shall be approvable as all the following:

- Labeled by the manufacturer as compliant with the product safety evaluation, testing, listing, and labeling program of an OSHA qualified product safety testing laboratory (“listing” means published by Make and Model with conditions and restrictions of use), and
- Compliant with conditions and restrictions of use listed by the test laboratory, and
- Compliant with NEC and WAC, Electrical Installations.

3.3.1.2 Field Evaluation and Testing by a Qualified Field Evaluation Body

Specifications for electrical equipment that is not listed and labeled by the manufacturer shall be approvable as one of the following:

- Field evaluated and tested by a FEB qualified by Washington State Department of Labor and Industry, for compliance with applicable ANSI standards for electrical product safety, or
- Labeled by Underwriters Laboratory (UL) 508A certified electrical fabrication shop (industrial control panels only), or
- Equipment connected to the load side of a NEC Article 725, *Class 1, Class 2, and Class 3 Remote- Control, Signaling, and Power-Limited Circuit*s, Class 2 or 3 power supply.

3.3.1.3 Unlabeled Electrical Equipment Not Conforming to Any American National Standards Institute Standard

Specifications for electrical equipment not exceeding 50 volts and not listed and labeled, and not evaluated by FEB, shall be approvable by a HLMI qualified NEC inspector or higher HLMI Authority Having Jurisdiction (AHJ).

Specifications for electrical equipment that is not listed and labeled by the manufacturer, and that does not conform to an ANSI standard suited to FEB evaluation and testing of product safety, and that requires or can create voltage exceeding 50 volts, shall be subject to approval of HLMI Design Authority for electrical distribution system and Electrical Engineering Discipline Lead before releasing the equipment specification for procurement.

3.4 Motors and Motor Controls

The following requirements shall apply to motor controllers for permanent processes that are likely in their life-cycle beyond start-up commissioning to encounter considerable maintenance and testing or diagnostic process manipulations, and to transportable processes that are likely to encounter multiple start-up commissioning exercises:

- Motor controllers shall be located to minimize hazards and difficulties of operation of the process and maintenance of equipment and systems
- Motor controllers shall be provided with all status indicators and controls beneficial to minimize hazards and difficulties of operation, operational testing, and maintenance
- Indicators and controls shall utilize the lowest practicable voltage, 24V where possible
- Where sufficient workspace exists, indicators and controls shall be installed in a separate electrical enclosure adjacent, or as nearby as practicable, to the motor controller enclosure
- Where there is not exceptionally harsh nor hazardous environment that would favor a remote location, the motor controller and the process indicators and controls shall be co-located with the motor and driven process equipment, to provide operation and maintenance with a clear view of the process being controlled
- Where the motor is in a hazardous environment, the motor controller and at least one set of status indicators and controls shall be in a hazard free location. Additional indicators and controls shall be co-located with the motor, wherever a clear view of the process could minimize hazards and difficulties of operation, operational testing, and maintenance in that environment
- Wherever practicable, motor controllers and associated industrial control equipment shall utilize “smart technology” such as intelligent overload relays and similar devices capable of sensing, storing, and feeding operational status and maintenance relevant data to facility monitoring and control systems.

Consideration should be given to specify Variable Frequency Drives (VFDs) as standard motor controllers, including motors that run only at full speed, for the value of process monitoring information available from VFDs, the reduction of start-stop impacts to electrical and mechanical systems, ability to sense faulted electrical circuits, and standardization of control systems equipment.

To minimize unnecessary exposure of personnel to electrical energy hazards, 480V motor controllers or VFDs shall not be combined into a common enclosure with other electrical or control system devices or equipment requiring less than 480V, such as 24V indicators or switches, or 120V controllers or relays.

3.4.1 Motor Control Centers

Motor Control Centers shall comply with Underwriters Laboratory standard, UL 845, *Motor Control Centers*.

3.4.2 Variable Frequency Drives

VFDs shall:

- Be factory labeled as compliant with an OSHA recognized testing laboratory safety program
- Be air cooled (to not require additional systems for cooling, such as a source of cooling water)
- Include the VFD manufacturer's standard NEC compliant electrical enclosures, and to the extent practicable, shall be available off-the-shelf and identifiable by the manufacturer's standard catalog numbering system.

Exception: *VFDs requiring custom enclosure design (shall be labeled UL 508 compliant),*

- *To control motors above 600 volts, or*
- *To control exceptionally high torque demands at reduced motor speed, or*
- *To survive an exceptionally harsh environment, or*
- *As a pre-determined component of a vendor engineered and packaged system or sub-system with no compliant VFD option, and no practicable alternative package vendor.*

Each VFD in a clean location shall include a local control interface labeled by the manufacturer as compliant with an OSHA recognized testing laboratory safety program. Where a custom design cabinet is necessary -- an industrial control cabinet labeled by a UL 508 shop -- the control interface shall be operable from outside the cabinet, or without exposing any electrical conductors carrying more than 50V.

Excepting any design requirement for a highly specialized and unusual VFD, each VFD shall possess optional communications capability (not necessarily installed at the time of VFD installation, depending on Design Authority approval of detailed project requirements) for remote monitoring and control, with at least one communications protocol option being Process Field Bus (PROFIBUS) or Industrial Ethernet PROFIBUS (PROFINET).

Each VFD disconnect switch or other lock-out device enclosure shall be separate from the VFD enclosure, either local or remote, so that everything inside the VFD enclosure is de-energized when locked out.

For each VFD, all configuration parameters that are not left at factory default values shall be identified as such, along with as-built configuration data for each of those parameters, in a technical document complying with HLMI-PRO-ENG-50439, *Technical Document Control*.

Each parameter affecting the behavior of overcurrent protection shall be further identified as overcurrent protection for fire prevention.

Because switching power supplies for electronic equipment have evolved to operate on most any conceivable international voltage irrespective of power quality, unless specified by Cognizant Electrical System Engineer as a project design requirement, harmonic analysis and other study are not required of the impact of a small VFD (≤100HP) on the surrounding electrical distribution system power quality and neighboring equipment.

For all VFDs, the manufacturer's published installation requirements and recommended accessory equipment specifications shall be provided for design verification. These requirements and specifications shall be intended to limit voltage spikes to less than the selected motor's electrical insulation level. They shall be tailored to the output voltage rise/fall time for the selected make and model VFD, and shall include:

- Limitations of energy storage in the wiring between the VFD and motor – acceptable material specifications and lengths of circuit
- Auxiliary electrical equipment performance specifications, where auxiliary equipment may restrain the rate of rise/fall of voltage at the motor, including required electrical impedance, and if available from the manufacturer, National Recognized Testing Laboratory (NRTL) listed equipment that can meet this performance specification.

This design requirement is not applicable to legacy VFDs (not likely equipped with IGBT output), where a proven unit-design by the vendor includes all motor and VFD output circuit specifications, i.e., legacy heating, ventilation and air conditioning units.

3.4.3 Motors

Unnecessary maintenance of electrical motors shall be minimized by the following design measures:

To the extent practicable (typically ¼ to ½ horsepower and larger, and 480V power available), motors for permanent systems shall be three-phase, to eliminate torque impulses of single-phase motors.

Design assumptions shall include that motors described by their manufacturer as "invertor duty," or compliant with National Electrical Manufacturers Association (NEMA) MG-1, *Motors and Generators*, Section 31, "Definite-Purpose Inverter-Fed Polyphase Motors" cannot withstand variable speed invertor operation without the protective design measures recommended by the VFD manufacturer for all the following:

- Specified motor insulation levels
- Installation physical arrangements of the VFD output wiring to the motor
- Specified VFD make and model.

For constant torque VFD applications, not for ventilation fans or centrifugal pumps, motors shall comply with NEMA MG-1 Section 31, on conveyors, positive displacement pumps, and hoists, and only where configured for "constant torque" mode.

Because equipment vendors are not always proficient with NFPA 70® design requirements, where a pump motor vendor also supplies motor cables, one of the following shall be verified during design review:

For constant torque VFD applications, not for ventilation fans or centrifugal pumps, motors shall comply with NEMA MG-1 Section 31, on conveyors, positive displacement pumps, and hoists, and only where configured for “constant torque” mode.

Because equipment vendors are not always proficient with NFPA 70® design requirements, where a pump motor vendor also supplies motor cables, one of the following shall be verified during design review:

- Ambient temperatures and requirement to calculate NEC compliant cable size have been specified for the vendor, and the cable sizing calculation provided by a vendor meets the requirements in HLMI-STD-ENG-50500, *Standards for Raceway Systems and Flexible Cords & Cables*
- Cable sizing calculation to meet the requirements in HLMI-STD-ENG-50500 has been performed by HLMI electrical design engineering and specified for the vendor.

3.5 Process Electronic/Electrical Indication and Control

3.5.1 General Process Indication and Control

Because analog electrical indicators are vulnerable to error from residual static charge after wiping clean for viewing, electronic and electrical process indicators shall be digital displays, not D’Arsenval movements.

Because as low as reasonably achievable considerations require that exposure to radiation and chemical hazards be limited as much as reasonably achievable:

- For electronic and electrical process indicators and controls, at least one location of primary process indication and control shall be outside of contaminated areas, e.g., collocated with the Motor Control Center (MCC), or available through Automated Control & Monitoring System (ACMS).

3.5.2 Emergency Stops

Emergency Stop buttons may be installed at accessible locations in proximity to hazardous machinery or process during operation, and in operator control stations nearest to having a view of, or within audible range of, such accessible hazards. Accessibility of hazardous machinery may consider, but need not credit procedural compliance, nor fitness for duty of personnel, removable machinery guards, nor training.

In no other location shall any control be identified for ‘emergency stop.’

Emergency Stop buttons should comply with ISO 13850, *Safety of Machinery — Emergency Stop Function — Principles for Design*:

Newly added safety requirement

ISO 13850: 2015

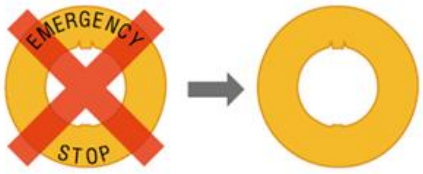
4.3.7

Neither the actuator nor the background should be labelled with text or symbols.

In this revision, it is not recommended to display texts or symbols such as EMERGENCY STOP on the actuator or nameplate of an emergency stop device. In order to accommodate the diversity of first languages of workers due to globalization, the revision aims to enable workers to have the following common recognition without the need to recognize texts or symbols:

A combination of a red actuator and yellow background = Emergency stop device (even if there are no texts/symbols)

Also, when a person intends to actuate an emergency stop device, it is expected that actuation following the recognition of only the color combination of red and yellow is faster than when there are texts/symbols.



Not recommended **Recommended**

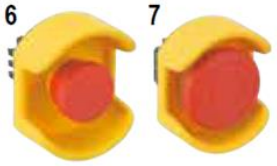
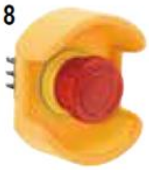
Emergency Stop buttons as applicable shall conform to NFPA 79, not limited to:

- Where control circuits perform safety-related functions, they shall meet the safety performance requirements determined by the risk assessment of the machine and the applicable functional safety standards
- The emergency stop shall function as either a Category 0 or a Category 1 stop
- Emergency stop switches shall not be flat switches or graphic representations based on software applications
- Emergency Stop shall be initiated by a single human action
- The actuator of a pushbutton-operated device shall be of the palm or mushroom-head type and shall affect an emergency stop when depressed.

NOTE: *International Standard for Organization (ISO) 13850:2015, Safety of Machinery – Emergency Stop Function – Principles for Design recommends that no label accompany an Emergency Stop button, as time is crucial to arrest immediate peril to life and health. Especially, other controls not intended to immediately arrest peril to life and health, must not labeled Emergency Stop.*

Controls intended to minimize damage to property or environment may be labeled 'Master Shutdown', 'System Shutdown', 'Shutdown', 'Stop', etc.

switch guard compliant with ISO 13850: 2015

Shape	Switch Guard Part No.	Applicable Model
ø22 	HW9Z-KG5	6: XW1E-BV4 : XW1E-LV4 : XW1E-TV4 7: XW1E-BV5
ø30 	XN9Z-KG1	8: XN1E-BV4 : XN1E-BV5 : XN1E-LV4 : XN1E-TV4

<TÜV Rheinland Japan Ltd confirmed>

Human factors during panic determine that Emergency Stop buttons are standardized to maximum simplicity.

Mounting height should be 60 to 67 inches. (79 inches is maximum mounting height in NEC 404.8(A). Alternatively, 5'7" is recommended by ISO 13850.)

Where all other means have been exhausted to prevent accidental activation of emergency stop, ISO 13850 enumerates the following order of preference:

- *Locate the control away from trafficked areas*
- *Select appropriate size and shape*
- *Use of shroud should be avoided where practical*

Practicality may be considered where an Emergency Stop cannot be relocated higher in the cabinet or into a new box. Switch guards installed for practical considerations must meet human factor requirements for palm activation by single action.

In no case is any cover permitted of an emergency stop button.

3.6 Safety Placards

In accordance with NEC Article 409.110, *Industrial Control Panels. Marking.* Where any electrical enclosure is supplied by more than one source exceeding 50V to ground, electrical design media shall incorporate and make explicit the following requirements:

- Multiple power sources shall be identified as a hazard by a "WARNING" placard conforming to American National Standards Institute, Z535.2-2011, *Environmental and Facility Safety Signs*
- Location of the placard shall be as nearly adjacent as practicable to any built in disconnect switch or to the enclosure access handle or latch
- Minimum size of the placard shall be specified as appropriate

- The following hazard symbol shall appear on the placard:

- The word messages shall include the following information, in order:
  - Hazard Description
  - Consequence of Interacting with the Hazard
  - Action/Avoidance Message.

- The default messages, when other design requirements (e.g., NFPA 70®, NEC Article 620.52, *Elevators*) do not specify all or part of the messages, shall be:

⚠ WARNING
MULTIPLE POWER SOURCES
Can shock, burn, or kill
Verify all Power Sources for Isolation as Applicable

3.7 Electrical Enclosures

3.7.1 Mounting Height and Workspace

Enclosures containing equipment other than wire and splices shall be mounted at a height accessible for all enclosed equipment while standing erect without stooping or crouching, or while seated on a portable workbench or stool.

Workspace protected by NFPA 70®, NEC Article 110.26, *Spaces About Electrical Equipment* and 3 feet beyond, shall be level without slope, steps, curbs, nor any other tripping hazards. No other structure, equipment, step, slope, or curb, less than 36 inches high shall be within 3 feet of the workspace protected by NFPA 70®, Article 110.26.

3.7.2 Environmental Ratings

Enclosures exposed to windblown dust shall either be:

- NEMA or International Electrotechnical Commission (IEC) rated resistant to windblown dust, or
- Known from previously documented experience to effectively prevent accumulation of dust, debris, and wildlife.

3.7.3 Operational Safety of Electrical Equipment

3.7.3.1 General

Equipment designed to allow access during normal operation shall be constructed such that an operator is not exposed to an electrical hazard above 50 volts during normal operation. The equipment shall be inherently safe from electrical hazards as defined by NFPA 70E, *Standard for Electrical Safety in the Workplace* without field modifications necessary to protect the equipment operator. This restriction does not apply to servicing and maintenance of the equipment that must be performed with the equipment energized. Specifications for off-site fabrication or design shall include this requirement.

3.7.3.2 Mixed-Voltage Hazards

The following should be considered by the design authority on a case-by-case basis for new designs or major modifications, based on practicality of implementation and benefit gained:

- For preventing mixed voltage hazards, an enclosure is the part of an electrical assembly that is accessible through a single access panel or door. Different sections of electrical equipment having multiple access doors or panels with factory installed barriers between sections, such as different MCC cubicles, are effectively different enclosures
- Conductors or equipment of different voltage potentials to ground should not be combined into a common enclosure with other electrical devices or equipment.
    - Exception 1: Different voltages less than 50 volts may be combined in a common enclosure
    - Exception 2: Transformers and power supplies in their own separate enclosure
    - Exception 3: Other single item of NRTL listed equipment in its own separate enclosure
    - Exception 4: Existing industrial control panels and MCC cubicles containing mixed voltage controls.
- Separate power supply enclosures may be co-located with control system enclosures, feeding only a lower voltage into the control system enclosure
- Multiple power supplies may be in a single enclosure, for example class 2 power supplies feeding several low voltage circuits to an enclosure for a large control system with more than 100 watts of 24-volt magnetic flow meters, solenoid valves, etc., power demands. However, transformers and power supplies of different voltages should not occupy the same enclosure
- To the maximum practical extent and wherever no great distances, power demands, and voltage drops are involved, control systems and instruments shall not exceed 50 volts
- PLCs with industrial communication networks and distributed input/output shall be utilized wherever practicable to limit voltages to less than 50 volts.

3.8 Equipment Ratings and Adjustments – Power, Amperage, Temperature

Electrical utilization equipment and instrumentation and controls that are located outdoors without enclosure, and are safety significant, or defense in depth, or support a Technical Safety Requirement, or collect critical data, or support compliance with an environmental requirement, or perform an documented function to assure safety of life, health or property including environment and financial assets, shall be rated by the manufacturer for the range of ambient temperature hazard listed as Design Basis Air Temperature in HLMI-STD-ENG-50492, *Environmental/Seasonal Requirements for HLMI Laboratory Systems, Structures, and Components* and based on HNF-SD-GN-ER-501, *Natural Phenomena Hazards*.

Adjustments in power ratings of electrical equipment that is located outdoors, to account for temperature rise and chronic effects on life of the equipment, shall be based on ambient temperature averaged over the time interval(s) published by the manufacturer with the equipment ratings, and for the period corresponding to worst seasonal combinations of ambient temperature and temperature rise with power loading.

Adjustments in amperage ratings of electrical wiring that is located outdoors above grade, using methods required by NEC for 3 hours of continuous operation, shall be based on most extreme 3-hour average high temperature as taken from the worst-case combination of seasonal ambient temperature and seasonal power loading temperature rise, or the highest temperature observed by Hanford Meteorological Station (HMS), 113 °F.

3.9 Electrical Elementary Diagrams

All modification of existing control panels, ‘Industrial Control Panel’ as defined by NFPA 70®, UL 508A, *Standard for Industrial Control Panels* and WAC 296-46B-903, “Equipment Standards” shall update the panel diagram to comply with current code, shall provide as necessary, new, or entirely revised Elementary Diagram conforming to HLMI-GD-ENG-50467, *Elementary Diagram Guide*, for each modified panel.

An Elementary Diagram for each control panel shall comply with the following:

- UL 508A, Article 61, “Schematic Wiring Diagrams”

  61.1 An industrial control panel shall be provided with a complete electrical schematic wiring diagram including all components provided by the manufacturer. Field installed components shown on the schematic wiring diagram shall comply with 60.3.

  For this requirement, Elementary Diagram drawing category shall be Essential. No other type of diagram or design detail shall be permitted on Elementary Diagrams. ‘Elementary Diagram’ shall appear in the title block. The control panel EIN shall appear immediately beneath the diagram. No panel layout or arrangement diagram shall be identified as a required drawing, rather may be developed by and for the panel fabrication and of interest to the fabricator only until EIN tags are in place.

The Elementary Diagram drawing number shall be linked to the EIN of the enclosure in SmartPlant Foundation.

- NEMA ICS-19, *Diagrams, Device Designations and Symbols for Industrial Controls and Systems*

  Schematic diagram; elementary diagram: A diagram that shows all circuits and device elements of an equipment and its associated apparatus or any clearly defined functional portion thereof. Such diagram emphasizes the device elements of a circuit and their functions as distinguished from the physical arrangement of the contactors, devices, or elements of a circuit system. Circuits that function in a definite sequence are arranged to indicate that sequence.

  This requirement includes all monitoring and control regardless of voltage, excepting only communication network cables, e.g., ethernet, Profibus. This requirement is not met by loop diagrams, wiring arrangement diagrams, block diagrams, interconnect diagrams, etc.

- NFPA 70® Article 409.110

  An industrial control panel shall be marked with the following information that is plainly visible after installation:

  (3) The location of the means necessary to disconnect all circuits 50 volts or more shall be documented and available.

  (6) Electrical wiring diagram or the identification number of a separate electrical wiring diagram or a designation referenced in a separate wiring diagram.

  This requirement invokes UL 508A/NEMA ICS-19 standard identification of 'associated equipment' using a dashed line surround or partition for every item of equipment not located in the control panel, complete identification of associated equipment by EIN, drawing/zone, and the voltage provided by associated equipment, and conversion of dashed line to solid line for 'future wiring' to equipment furnished by installer/customer.

- NFPA 70® Article 430.74 *Electrical Arrangement of Control Circuits*

  Where one conductor of the motor control circuit is grounded, the motor control circuit shall be arranged so that a ground fault in the control circuit remote from the motor controller will (1) not start the motor and (2) not bypass manually operated shutdown devices or automatic safety shutdown devices.

  As industry best practice for consistent Human Performance, this requirement applies to arrangement of ALL control circuits such that nothing can be activated or energized by collision or other accident, fire, or catastrophe causing a wiring fault to ground.

- HLMI-GD-ENG-50467, *Elementary Diagram Guide*

  Elementary Diagrams shall serve the purpose of electrical sensing and control design development, checking, and verification early in design that the electrical circuits and device elements shall meet all functional requirements, including NEC, UL, WAC, and HLMI engineering standards and guidance.

Elementary Diagrams shall be the basis for development and back checking of physical wiring design layout and routing, including development and checking of:

- Loop wiring connection diagrams (limited to 24VDC nominal) that may be useful to layout sensing or control circuits in twisted shielded wire pairs
- Block wiring connection diagrams that may be useful to layout sensing or control circuits among different enclosures
- Elementary Diagram drawings shall be limited to Elementary Diagrams, not mixed with other types of wiring layout or routing diagrams.

3.10 Unique Conduit and Wire Run Numbering

Large project construction and installation work by electrical contractors at Hanford have benefitted from the use of unique numbers for the scope of the project work, using a single conduit schedule and a single wire run list, each comprised of serial numbers. However, due to facility modifications beyond the scope of original construction, conduit and wire run identification is not assured to be unique at any Hanford facility.

Unique conduit and wire run numbers are available for raceway and wire runs using SmartPlant® Foundation (SPF). However, only sequence numbers issued after the release of Revision A-5 of this standard are unique. These do not make any existing facility conduit or wire run numbers unique. Unique conduit and wire run numbers are not normally required for maintenance, operations, nor for projects or facility modifications.

Tag types are available under Electrical Equipment in SPF, and use the following component acronyms. Conduit and wire run equipment numbers follow the standard equipment numbering convention described in HLMI-STD-ENG-50498, *Equipment Identification Numbering and Labeling Standard*.

- ERP Electrical Raceway, Power
- ERS Electrical Raceway, Signal
- EWR Electrical Wire Run.

4.0 DEFINITIONS

Term	Definition
AHJ	NFPA avatar, “authority having jurisdiction,” whoever enforces NFPA codes and standards. • Inspector normally enforcing National Electrical Code. • Higher authority responsible to resolve issues, approve equivalent safety.
FEB	Field Evaluation Body qualified to NFPA 790 or Washington State Department of Labor and Industry
Labeled	Identified by the manufacturer’s permanent marking of a product, as compliant with the listing of that product's OSHA qualified safety evaluation and testing laboratory.
Listed	Appearing by Make and Model in the database published and maintained by a product safety evaluation and testing laboratory qualified by OSHA, with detailed information on the applicable OSHA recognized product safety standard(s), associated limitations and conditions of use, and product labeling.

5.0 FORMS

None

6.0 RECORD IDENTIFICATION

No records are generated during the performance of this procedure.

7.0 SOURCES

7.1 Requirements

10 CFR 851.23, *Worker Safety and Health Program*

29 CFR 1910.399, *Occupational Safety and Health Standards, Electrical, Definitions, Acceptable*

29 CFR 1910.7, *Definition and Requirements for a Nationally Recognized Testing Laboratory*

DOE O 252.1A, *Technical Standards Program*

DOE-0359, *Hanford Site Electrical Safety Program*

HLMI-PLN-ASYS-51063, *Quality Assurance Program Description*

International Standards Organization 13850:2015, *Safety of Machinery – Emergency Stop Function – Principles for Design*

National Fire Protection Association (NFPA) 70®, National Electric Code®

NFPA 790, *Standard for Competency of Third-Party Field Evaluation Bodies*

NFPA 791, *Recommended Practice and Procedures for Unlabeled Electrical Equipment Evaluation*

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