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D3060/F1050 INSTRUMENTATION AND CONTROL (I&C)

Note: Sections which are applicable to Programmatic and Facility SSCs will be followed by **(P & F)**

RECORD OF REVISIONS

Rev	Date	Description	POC	OIC
0	5/22/02	Initial issue	Mel Burnett, *FWO-SEM*	Kurt Beckman, *FWO-SEM*
1	11/17/03	Revised initial issue contents for clarity and added information. Expanded the section (Additional Requirements for Safety-Related Systems) to include installation requirements and guidance for safety-related systems, the application of IEEE 384, and the application of ISA 84.01-1996. Added the following sections: Environmental Considerations, Computer/Control & Data Processing Systems and Equipment, Color Conventions for Process Displays, and Grounding Practices. Added first seven appendices.	Mel Burnett, *FWO-DECS*	Gurinder Grewal, *FWO-DO*
2	5/18/05	Made P&F designation consistent; emphasized requirement for application of IEEE 384; converted endnotes to footnotes; added Appendix H.	Mel Burnett, *ENG-DECS*	Gurinder Grewal, *ENG-CE*
3	10/27/06	Administrative changes only. Organization and contract reference updates from LANS transition; 420.1A became 420.1B. IMP and ISD number changes based on new Conduct of Engineering IMP 341. Master Spec number/title updates. Moved PFD/PID material from Mech Chapter to App I. Other administrative changes.	Mike Clemmons, *FM&E-PSE*	Kirk Christensen, *CENG*

PLEASE CONTACT THE I&C STANDARDS POC
for upkeep, interpretation, and variance issues

Section D3060/F1050	**Instrumentation & Controls POC/Committee**

1.0 APPLICATION OF THIS CHAPTER

1.1 General

A. The purpose of this chapter of the LANL Engineering Standards Manual (ESM) is to ensure I&C systems are designed to prevent accidents and mitigate consequences; are efficient, convenient, and adequate for good service; and are maintainable, standardized, and adequate for future expansion.

B. *This chapter, along with other chapters of the Engineering Standards Manual, comprehensively implements requirements and guidance in DOE O 420.1B, Facility Safety, and its two guides, (1) DOE G 420.1-1, Nonreactor Nuclear Safety Design Criteria and Explosive Safety Criteria Guide for use with DOE O 420.1 Facility Safety and (2) DOE G 420.1-2, Guide for the Mitigation of Natural Phenomena Hazards for DOE Nuclear Facilities and NonNuclear Facilities, along with providing additional requirements.*

C. Use this chapter along with Chapter 1-General, Chapter 7-Electrical, Chapter 10-Hazardous Process, Chapter 12-Nuclear and other ESM chapters as applicable.

D. LANL has the authority to grant variance to any requirement herein not driven by Order 420.1B.

WARNING: Failure of nuclear facilities/activities to comply with the DOE O 420.1B requirements in this chapter could result in civil and criminal enforcement under the Price Anderson Amendments Act because 10 CFR 830 invokes 420.1B. LANL cannot wavier 420.1B requirements without going through a formal process with NNSA (e.g., LASO) concurrence.

Note: Guidance statements are in *italics* or are otherwise clearly indicated.

E. All **facility**-related I&C design, material, equipment, and installations shall comply with site-specific requirements in this Chapter and Chapter 1 of the ESM. Requirements in this Chapter that also apply to **programmatic** work are addressed in Section 1.3.

F. When new LANL Standards requirements are issued, refer to ESM Chapter 1 Section Z10, Code of Record subsection, for application considerations.

G. Where appropriate, guidance is provided to aid the cost-effective implementation of site-specific requirements and the requirements in the applicable codes. *Italicized* text identifies recommended guidance (not mandatory), based on good business practice and through lessons-learned at LANL. All other text in regular type indicates **mandatory** requirements unless prefaced with wording identifying it as guidance or a recommendation.

H. In addition to new I&C installations, this chapter applies to some renovation, replacement, modification, maintenance, or rehabilitation projects. Refer to ESM Chapter 16-IBC Building Safety Program, for requirements.

I. The adequacy of all design inputs is the responsibility of the designer/design agency. If the designer believes the ESM to be incorrect (e.g., compliance will cause a problem), it is their responsibility to bring the issue to the attention of the ESM Discipline POC (via the Project Manager if appropriate) for resolution. All Variances, Clarifications, Interpretations, and Exceptions should be documented per ESM Chapter 1, Section Z10.

J. Nuclear: For such projects, Chapter 12-Nuclear and its Appendixes provide additional requirements for applicable or covered systems to the disciples listed in Table 1-1 below.

K. *Responsibility for the design of I&C, mechanical, and electrical systems can vary across organizations. Because this is a new chapter, the following table is included to show how LANL has distributed certain standards information between this and other ESM chapters.* ***NOTE****: Coordination between the discipline designers is essential to achieve the best systems.*

TABLE 1-1

Ch 7-Electrical	***Ch 8-I&C***	***Ch 6-Mechanical***	***Ch 2-Fire Protection***
All power and control wiring.	*Controllers and processors for real-time control of mechanical, lighting, or building energy system monitoring.*	*Fluid controlling devices such as valves and dampers with the associated actuators.*	*Identification of fire protection related safety control functions required above and beyond those required in Chapter 2 and related Master specifications.*
Power supplies and UPS systems.	*Sensors and transmitters (temperature, humidity, flow, pressure, orifice plates, thermowells, flow measuring arrays and stations, etc.).*	*Local mechanical (non loop) indicators such as gauges and thermometers.*	*Building construction features such as materials of construction, fire resistance ratings, fire doors, fire dampers, fireproofing and fire-stopping materials.*
Power switches, breakers, and relays	*Self-contained controllers such as thermostats and humidistats.*	*Instrumentation tubing and isolation valves.*	*Features of fire suppression systems addressed in Chapter 2 and related Master specifications.*
Electrical protective relays and devices.	*Reference pressure devices.*	*Instrument air delivery systems.*	Fire alarm systems addressed in Chapter 2 and in LANL Master Specifications Sections 28 3100 and 28 3110.
Motors, motor starters, and variable frequency drives (VFDs).	*Low voltage switches and relays used as output devices to control mechanical systems.*		
Current and potential transformers used for electric metering and protection functions.	*Current transformers and relays used for status monitoring.*		
Electrical distribution monitoring and control.	*Fire Protection related process safety interlocks that are in addition to the requirements in ESM Chapters 2 and 7.*		

1.2 Exclusions

A. The following are excluded from the requirements of this chapter.

1. Fire alarm systems and fire sprinkler systems that do not have safety related interlocks and that are designed and installed in compliance with Chapters 2 and 7 of the ESM including the associated specifications.
2. Systems and devices providing security functions and controlled by SEC-Division.
3. Systems and devices that have the primary purpose of controlling vehicular and/or pedestrian traffic.

1.3 Programmatic

A. The I&C chapter shall be applied to programmatic systems and components as follows:

1. Headings in this Chapter followed by "**P&F**" indicate that subsection shall be complied with by all of LANL, including programs.
2. *Guidance: Programmatic personnel should review all topics in the chapter for relevant material when initiating any design task.*

2.0 ACRONYMS AND DEFINITIONS

For other definitions, refer to ESM Chapter 1, Section Z10.

Acronym	Definition
AHJ	Authority having jurisdiction
ASHRAE	American Society of Heating, Refrigeration & AC Engineers
CFR	Code of Federal Regulation
DES	FM&E Division's Design Engineering Services Group
Design Agency	The organization performing the detailed design and analysis of a project or modification.
Design Authority	Refer to IMP 342 or ESM, Chapter 1, Section Z10 for this definition.
Design Documents	Design Documents are those design-related documents that define or otherwise control the final design, operation, or maintenance of a facility or program. Examples of design documents include drawings, as-builts, calculations, vendor manuals, equipment and document lists, studies, reports, and design specifications.
Design Input Specification	A Design Document prepared for Safety Related systems, with emphasis on conditions unique to the facility and subject process.
ESM	[LANL] Engineering Standards Manual

Acronym	Definition
Facility	A synonym for Real Property and Installed Equipment. RP&IE is the land, improvements on the land such as buildings, roads, fences, bridges, and utility systems and the equipment installed as part of the basic building construction that is essential to normal functioning of a building space, such as plumbing, electrical and mechanical systems. This property/equipment is also referred to as institutional or plant and was formerly known as Class A. [ref DOE Order 433.1].
FM&E	Facility Management & Engineering Division
IEEE	Institute of Electrical and Electronics Engineers
ISA	The Instrumentation, Systems, and Automation Society
LMSM	LANL Master Specifications Manual
LIG	Laboratory Implementation Guidance
LIR	Laboratory Implementation Requirements
Major Project	Construction project greater than $500k (CPM LIR 220-01-01)
Master Equipment List (MEL)	The MEL is a controlled hardcopy or electronic database of facility, and applicable programmatic SSCs. The MEL captures and controls equipment information such as identification number, name, function, location, vendor data, design information, management level, and reference documentation.
ML-1	Management Level 1 (ML1) - Rigorous application of applicable codes, standards, procedural controls, verification activities, documentation requirements, and formalized maintenance program. Could include facility work for which independent review and management approvals for such things as design verification, procurement, fabrication, installation, assembly, and construction are considered essential. See AP-341-502 Management Level Determination for Structures, System, and Components
ML-2	Management Level 2 (ML2) - Selective application of applicable codes, standards, procedural controls, verification activities, documentation requirements, and formalized maintenance program (i.e., certain elements may require extensive controls, while others may only require limited control measures). Could include facility work that may require independent review, management approval, and verification of design outputs, surveillance during procurement, fabrication, installation, assembly, and construction.
ML-3	Management Level 3 (ML3) - Application of appropriate codes, standards, procedural controls, verification activities, and documentation requirements that are consistent with recognized industry practices. Could include facility work that is normally manufactured, installed, assembled, and/or constructed in accordance with recognized codes and standards.

Acronym	Definition
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
POC	Point of contact. For ESM chapter/discipline Technical Committee POCs see http://engstandards.lanl.gov/engrman/HTML/poc_techcom1.htm
Programmatic	A synonym for Personal Property and Programmatic Equipment. PP&PE is equipment used purely for programmatic purposes, such as reactors, accelerator machinery, chemical processing lines, lasers, computers, machine tools, etc., and the support equipment dedicated to the programmatic purpose. This property/equipment is also referred to as organizational, research, production, operating or process and was formerly known as Class B. [archived DOE Order 4330.4B].
Safety Class (SC)	Systems, structures, or components including primary environmental monitors and portions of process systems, whose failure could adversely affect the environment, or safety and health of the public as identified by safety analyses. [10 CFR 830.3].
Safety-Related	A term meaning safety class, safety significant, and those ML-1 and ML-2 SSCs that could potentially impact public or worker safety or the environment in the same way as safety class or safety significant systems respectively.
Safety Significant (SS)	Structures, Systems, and Components that are not designated as Safety-Class SSCs but whose preventive or mitigative function is a major contributor to defense in depth and/or worker safety as determined from safety analyses. [10 CFR 830.37] As a general rule of thumb, Safety-Significant SSC designations based on worker safety are limited to those Systems, Structures, or Components whose failure is estimated to result in a prompt worker fatality or serious injuries or significant radiological or chemical exposures to workers. The term, serious injuries, as used in this definition, refers to medical treatment for immediately life-threatening or permanently disabling injuries. (e.g., loss of eye, loss of limb).
Safety Significant Instrumented System (SSIS)	An SS system or 29 CFR 1910.119 hazardous process independent protection layer that requires instrumentation, logic devices and final control elements to monitor and detect a ML-2/SS event, and which will result in automatic or operator action that will bring the facility or process system to a safe state.
Small Construction Project	Construction project below $500k.
SRS	Savannah River Site

Acronym	Definition
Structure, System, and Component (SSC)	Structure, System, and Component are defined as "Structure is an element, or a collection of elements to provide support or enclosure such as a building, free standing tank, basins, dikes, or stacks; System is a collection of components assembled to perform a function such as piping, cable trays, conduits, or heating, ventilation, and air conditioning; and Component is an item of equipment such as a pump, valve, or relay , or an element of a larger array such as a length of pipe, elbow, or reducer.
System Design Description (SDD)	A document defining a facility safety or mission-important system. The system design description consolidates existing system designs and presents design basis requirements imposed on the system by governing criteria and analyses that dictate system design features and configurations.

3.0 CODES ANDSTANDARDS (P&F)

3.1 General

A. Refer to ESM Chapter 1, Section Z10 for general requirements, such as variances and graded approach.

B. **Listed Equipment**: All permanently installed programmatic I&C equipment and all ML-1, ML-2, and ML-3 facility I&C equipment shall be Nationally Recognized Testing Laboratory (NRTL) listed (e.g., UL, TUV, FM, etc.) and shall only be used for the purpose in which it is intended in accordance with its listing or Electrical Safety Officer approval. Control panel completed assemblies shall have UC508 certification and associated UL508 sticker. *Guidance: All other programmatic I&C installations should be Nationally Recognized Testing Laboratory (NRTL) listed equipment (e.g., UL, TUV, etc.) and should only be used for the purpose in which it is intended in accordance with its listing whenever possible.*

C. **Prototype or Temporary Installations:** Prototype programmatic equipment or temporary (less than 90 days) facility or programmatic equipment must be installed in accordance with and meet the requirements of LIR 402-600-01 (Electrical Safety). *Guidance: Peer review of the system design is especially useful and highly recommended for prototype installations.*

3.2 National Codes and Standards – Task Matrix

A. The following application matrix (Table 3-1) identifies the minimum set of codes and standards that shall be applied to safety-related I&C systems and the recommended set for ML-3/general service systems -- consistent with their applicability for the specific technical or performance function. For safety-related systems, the requirements of the codes and standards shall be applied in a graded approach and documented in accordance with Section 3.1.D.

Table 3-1
Standards for I&C Systems

		Safety-Related	
Component / Function	**ML-3 or General Service (Recommended)**	**ML-2 or Safety Significant (Required)**	**ML-1 or Safety Class (Required)**
General	*ISA 5.1 and 5.3; IEEE N323*	ISA series especially 5.1, 5.2, 5.3, 5.4, and 84.01-1996; NFPA 70 and 110; ANSI/IEEE C2, N323; IEEE, 141, 142, 242, 493, and 1050; DOE G 420.1-1.	ISA series especially 5.1, 5.2, 5.3, and 5.4; NFPA 70 and 110; ANSI N320; ANSI/IEEE C2, N323; IEEE 141, 142, 242, 323, 336, 338, 344, 379, 384, 493, and 1050; DOE G 420.1-1.
Scaling	*ISA 67.04*	ISA 67.04	ISA 67.04
Monitoring	*HPS ASC N13; IEEE N42.18; NFPA 70; ANSI N13 series*	HPS ASC N13; IEEE N42.17B, N42.18; NFPA 70[1]; ANSI N13 series, ANS 8.3 (criticality only)	HPS ASC N13; IEEE N42.17B, N42.18; NFPA 70 ANSI N13 series ANS 8.3 (criticality only)
Programmable Digital Equipment	*IEEE 1046 and 1289; ANS 10.5; NUREG 0700*	IEEE 1046 and 1289; ANS 10.5; NUREG 0700	IEEE 1046 and 1289; ANS 10.5; NUREG 0700
User Interface		IEEE 1023	IEEE 1023
Ventilation (Uniformat D3060)		ASME AG-1, N509 and N510	ASME AG-1, N509 and N510

[1] Identified for use in 6430.1A, Section 1300-6.5.5. ANSI N2.3, Evacuation Alarm Systems, listed in DOE G 420.1-1, was withdrawn.

Titles for Table 3-1

ANS 8.3, Criticality Accident Alarm System
ANS 10.5, Accommodating User Needs in Computer Program Development

ANSI/IEEE C2, National Electrical Safety Code [NESC]
ANSI/IEEE N320, Performance Specifications for Reactor Emergency Radiological Monitoring Instrumentation
ANSI N13 series addresses radiation monitoring equipment

ASME AG-1, Code on Nuclear Air and Gas Treatment
ASME N509, Nuclear Power Plant Air-Cleaning Units and Components
ASME N510, Testing of Nuclear Air-Cleaning Units and Components

DOE G 420.1-1, Nonreactor Nuclear Safety Design Criteria and Explosive Safety Criteria Guide for use with DOE O 420.1 Facility Safety

HPS ASC N13, Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities [Health Physics Society Accredited Standards Committee]

IEEE
N323, Radiation Protection Instrumentation Test and Calibration (ANSI/IEEE)
N42.17B, Radiation Instrumentation Performance Specifications for Health Physics Instrumentation – Occupational Airborne Radioactivity Monitoring Instrumentation
N42.18, Specification and Performance of On-Site Instrumentation for Continuously Monitoring Radioactivity in Effluents (ANSI/IEEE)
141, Recommended Practice for Electrical Power Distribution in Industrial Plants (IEEE Red Book)
142, Recommended Practice for Grounding of Industrial and Commercial Power Systems (IEEE Green Book)
242, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (IEEE Buff Book)
323, IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations
336, IEEE Standard Installation, Inspection, and Testing Requirements for Power, Instrumentation, and Control Equipment at Nuclear Facilities

IEEE (continued)
338, IEEE Standard Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems
344, IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations
379, IEEE Standard Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety Systems
384, IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits
493, Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems (IEEE Gold Book)
1023, IEEE Guide for the Application of Human Factors Engineering to Systems, Equipment, and Facilities of Nuclear Power Generating Stations
1046, Application Guide for Distributed Digital Control and Monitoring for Power Plants
1050, IEEE Guide for Instrumentation Control Equipment Grounding in Generating Stations
1289, Guide for the Application of Human Factors Engineering in the Design of Computer-Based Monitoring and Control Displays for Nuclear Power Generating Stations

ISA [all formerly ANSI/ISA "S" series]
5.1, Instrumentation Symbols and Identification
5.2, Binary Logic Diagrams for Process Operations
5.3, Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computer Systems
5.4, Instrument Loop Diagrams
67.04, Setpoints for Nuclear Safety-Related Instrumentation
84.01-1996, Application of Safety Instrumented Systems for the Process Industries

NFPA 70, National Electrical Code [NEC]
NFPA 110, Standard for Emergency and Standby Power Systems; also NFPA 110A

NRC NUREG-0700, Guidelines for Control Room Design Reviews

4.0 DESIGN DOCUMENTATION (P&F)

4.1 General

A. The baseline Design Documentation (Design Input Specifications and Design Drawings) is to be established at a level commensurate with the management level/safety classification of I&C systems and/or devices in accordance with DOE-STD-1073, "Configuration Management Program." At a minimum, P&ID Drawings, Instrument Loop Drawings, Control Logic Drawings, and Schematic Drawings shall be considered priority drawings for all safety-related systems. The drawing guidance shall be considered requirements for safety related SSCs.

B. The following provides a graded approach for determining when priority drawings are required.[2]

1. For all ML-1 SSCs
2. For all ML-2 SSCs, and
3. For ML-3 SSCs that provide a mission critical, defense in depth, or worker safety function or whose failure may impact operation of ML-1 or ML-2 SSCs.

C. Priority Drawings shall be part of the Project Record Documents provided to LANL **prior** to formal Construction Project Acceptance. Refer to required Appendix I on PFD and P&ID Diagram requirements and this chapter's Appendices F through H for guidance on the other drawing types.

D. Drawing content and format shall comply with the LANL Drafting Manual including its Mechanical section (*Section 305*) and Electrical section *(Section 306).*

E. A Design Input Specification shall be developed for Safety-related systems to include, as applicable, the following items: [3]

1. Performance requirements for all plant operating conditions (accident and normal) wherein the equipment is expected to perform an intended function.
2. Ambient and process operating conditions including the measured variable for each of the applicable operating modes and conditions.
3. The minimum and maximum ambient temperatures to which the I&C system devices will be subjected.
4. The minimum and maximum pressures to which the I&C system devices will be subjected.

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[2] LIR240-01-01.2, Facility Configuration Management. This implementing requirement refers to "logic" drawings as part of the priority drawing set.

[3] Taken from ASME AG-1-1997, "Code on Nuclear Air and Gas Treatment" – Article IA-4120, and supplemented by SRS Standards, Guides, and Engineering Manual E7. The listing identifies the necessary input that is required for the selection of appropriate I&C devices.

5. The minimum and maximum relative humidity to which the I&C system devices will be subjected.
6. The cumulative dosage levels (alpha, beta, and gamma) and maximum dose rates to which the equipment will be subjected under the operating conditions.
7. Concentration and duration of chemical exposure to which the equipment will be subjected.
8. All electrical power transients and normal power fluctuations to which the I&C system devices may be subjected.
9. Structural/Vibratory loads to which the instrumentation and control system components, enclosures, or supports will be subjected.

Guidance: The above items that constitute a Design Input Specification should be addressed for any I&C system, as applicable or practical.

F. A System Design Description shall be developed for Safety-Related I&C systems, or those I&C systems that provide a mission critical, defense in depth, or worker safety function, whose failure may impact the operation of safety-related SSCs, and when required by other ESM Chapters including Ch 1 Section Z10. [4] **Note:** The SDD shall be submitted as part of the project record documents prior to project acceptance. The content of the system design description shall be based on DOE-STD-3024 and shall document the purpose (design function) and safety classifications for the I&C components, and sections or subsections shall be added to ensure the following content is adequately addressed:[5]

   1. System and Component Functions
   2. System and Component Design Requirements or Constraints
   3. Operation Description
   4. Set Points and System Limitations (Expected Values or Ranges)
   5. Expected System Upsets and Methods/Procedures for Recovery
   6. Maintenance Requirements and Recommendations
   7. Bases for Design Requirements
   8. Interface Requirements
   9. References

G. Any necessary calculations shall be performed and documented according to AP-ENG-605, "Developing and Revising Engineering Calculations", its successor, or an equivalent procedure.

[4] ESM Ch 1 Section Z10 also includes requirements on SDD need and content.
[5] The list establishes the essential content for a System Design Description and was developed by SRS in accordance with DOE-STD-3024, "Content of System Design Descriptions." The required content is mandated by SRS through the SRS Engineering Manual E7.

H. *Guidance: As part of the Project Record File, when required, the following documentation should be obtained from the Manufacturer of I&C system devices, as applicable:*[6]

1. *Mounting connection details*
2. *Weight and center of gravity*
3. *Service connections, size, type, and locations*
4. *Materials of construction*
5. *Design life*
6. *Environmental and seismic qualifications*
7. *Mounting restrictions and instructions*
8. *Loop and logic diagrams*
9. *Electrical schematic and wiring drawings*
10. *Panel general arrangement and construction drawings*
11. *Instrument piping and tubing drawings*
12. *Certificate of conformance*
13. *Calibration procedures and data*
14. *Panel mounted instrument list including nameplate engraving*
15. *Maintenance and surveillance requirements*
16. *Recommended spare parts listing*
17. *Specification data sheets for components, parts, or system*

I. *Guidance: ISA-20-1981, "Specification Forms for Process Measurement and Control Instruments, Elements, and Control Valves" should be used to assist in procurement of instrumentation equipment. These data sheets are available from FM&E-DES.*

5.0 ENERGY CONSERVATION/SUSTAINABLE DESIGN

A. See ESM Chapter 14, Sustainable Design.

B. Provide a computerized Building Automation System in all new, air-conditioned buildings larger than 10,000 square feet.[7] For Buildings smaller than 10,000 square feet, provide connection of important equipment to LANL ESS system to report equipment failure and possible freeze conditions.

1. Follow LANL Master Specifications, Section 25 5000, Integrated Automated Facility Controls.

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[6] The document listing is taken from ASME AG-1-1997, "Code of Nuclear Air and Gas Treatment," and identifies the types of I&C documentation that should be requested from the manufacturer.

[7] Pays back in energy savings and supports sustainable design requirements in DOE Order 430.2A, DOE O 413.3, and 10CFR435.

C. HVAC control systems design, materials, and construction are an integral component of sustainable design. Design I&C systems and specify equipment for compatibility with the building and site aesthetics, lighting and electrical systems requirements, and indoor environmental quality requirements to ensure that multi-discipline whole-building sustainable design practices are followed.

1. *Guidance: Refer to the Green Building Council's LEED rating system and other resources at http://www.usgbc.org/DisplayPage.aspx?CategoryID=20 and DOE/GO-102001-1165, Greening Federal Facilities; An Energy, Environmental, and Economic Resource Guide for Federal Facility Managers and Designers. http://www.nrel.gov/docs/fy01osti/29267.pdf*

6.0 EQUIPMENT IDENTIFICATION (P & F)

A. Identify major I&C equipment in accordance with the nomenclature indicated in LANL Engineering Standards Manual, Chapter 1, Section 200, Equipment & Component Numbering and Labeling.

B. Label I&C equipment in accordance with LANL Master Specification 22 0554, Identification for Plumbing, HVAC, and Fire Piping and Equipment, and LANL Master Specification 26 0553, Identification for Electrical Systems, as applicable.[8]

[8] LIR/LIG 402-100-01, Signs, Labels, and Tags (future ISD 101-19, Signs, Labels, and Tags); and 1997 IAPMO UPC, Section 601.2.

7.0 ENVIRONMENTAL CONSIDERATIONS[9] (P & F)

A. The requirements identified within this section are for Safety-Related I&C systems or those I&C systems that provide a mission critical, defense in depth, or worker safety function or whose failure may impact the operation of Safety-Related SSCs. For other non-safety I&C systems, all items in this section shall be interpreted as guidance that establishes sound engineering practice for the proper and reliable performance of I&C systems.

7.1 General

A. The environmental conditions in which I&C equipment must operate or which can affect the proper or continued operation of I&C equipment shall be clearly identified and considered in I&C design and equipment selection. Normal ambient, abnormal operating, climatic and event conditions shall be evaluated in the identification of applicable environmental conditions.

Guidance: The environmental factors that should be considered when selecting equipment location or equipment for a location include, but are not limited to, the following:

1. *Temperature and/or Humidity Extremes*
2. *Barometric Pressure Variations*
3. *Airflow*
4. *Corrosive Atmospheres*
5. *Area Flooding*
6. *Acoustic Noise*
7. *Electronic Noise, or Electromagnetic Interference (EMI)*
8. *Power Supply Quality (electrical surges, frequency variations, etc.)*
9. *Grounding*

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[9] The requirements identified within the Environmental Considerations section are "Good Engineering Practice" and must be established for Safety-Related systems to ensure that the environment in which the systems will be placed is conducive to the performance attributes of the selected I&C components. DOE G 420.1-1, Section 5.1.1.3, establishes the requirement for Environmental Qualification as deemed necessary to ensure reliable performance of a safety system under those conditions and events for which it is intended.

The requirements and guidance within the section are developed through several standards. ASME AG-1, "Code on Nuclear Air and Gas Treatment," Article IA-4000 – Design Considerations, requires the identification of environmental conditions for safety-related systems. Additional requirements and guidance were developed through several standards that identify environmental conditions that could adversely impact the operability of I&C equipment. These standards establish methods to recognize and classify such environmental conditions. The standards are provided as follows:

- ISA-71.01, "Environmental Conditions for Process Measurement and Control Systems: Temperature and Humidity"
- ISA-71.02, "Environmental Conditions for Process Measurement and Control Systems: Power"
- ISA-71.03, "Environmental Conditions for Process Measurement and Control Systems: Mechanical Influences"
- ISA-71.04, "Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants"
- IEEE 1-2000, "Recommended Practice – General Principles for Temperature Limits in the Rating of Electrical Equipment and for the Evaluation of Electrical Insulation"
- IEEE-1159, "Recommended practice for Monitoring Electric Power Quality"
- IEEE-1100, "Recommended Practice for Powering and Grounding Electronic Equipment IEEE Emerald Book."

10. *Lighting*
11. *Lightning Protection*
12. *Physical Security*
13. *Vibration*
14. *Interference from Large Motors and Power Feeders*
15. *Chemical and Particulate (dust) Contamination*
16. *Radiation*
17. *Elevation above sea level*

B. The I&C equipment that is required to meet performance specifications may necessitate a specific type of environment, or in other cases, the environment may limit the choice of equipment. Where I&C equipment cannot be found that will provide the required performance in the environmental conditions present, alternate means shall be provided such as heated, cooled, waterproof, corrosion protective and similar enclosures. For enclosures or other environment protective devices, their effect on equipment performance, ability to test, and effect on calibrations shall be evaluated.

C. All environmental restrictions imposed by the manufacturer of the equipment shall be met. If several types of equipment are to be located within the same environment, the environment must satisfy the most restrictive of all the equipment specifications.

Guidance: In extreme cases, the equipment climate may require very close control over all environmental aspects. In some instances, sensitive equipment may be placed in a sealed enclosure, so that only a relatively small volume would need to be protected. The more rugged equipment, such as programmable controllers, industrialized PCs, or MIL-Spec equipment, can usually be installed and maintained under the existing ambient conditions. Hazardous areas may necessitate the use of intrinsically safe equipment, explosion-proof enclosures, sealing and purging, etc.

D. If I&C equipment is to be located in Class I, Divisions 1 and 2; Class II, Divisions 1 and 2; or Class III, Divisions 1 and 2 locations, where fire or explosion hazards may exist due to flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers, the requirements of NFPA 70 (NEC) – Articles 500 through 504 shall be met.

Guidance: ANSI/ISA-RP12.06.01, "Wiring Practices for Hazardous (Classified) Location Instrumentation – Part 1: Intrinsic Safety", provides guidance in the design, installation, and maintenance of intrinsically safe I&C systems for hazardous (classified) locations. This recommended practice should be used in conjunction with the requirements of Article 504 of the NEC.

7.2 Specific Considerations

A. Temperature: The temperatures to which I&C equipment may be exposed in the application shall be clearly identified. The temperatures of concern shall be evaluated against the specified operational temperature requirements for the selected equipment to ensure compatibility. If equipment selection is not conducive to the given temperature conditions, alternate measures shall be taken, such as the use of the temperature-controlled enclosures.

Guidance: The temperature of concern is the temperature of the medium (whether air or liquid) which affects or cools the equipment. In regard to fan-cooled equipment, the temperature of concern is that of the air entering the equipment. Operational temperature requirements for equipment is normally well defined in the manufacturer's literature. Two separate temperature ranges are typically specified, one for when the equipment is in operation and another for when the equipment is powered-down, shipped, or in storage. Operating temperatures may also be specified as ambient, which refers to the surrounding temperature, and process, which refers to the process media being measured. The manufacturer's equipment specifications may also include a maximum allowable rate of change of temperature, given in degrees per hour.

B. Airflow: The design and control of airflow systems shall consider both equipment locations and normal airflow patterns.

Guidance: Airflow in fan-cooled and convection-cooled equipment is generally vertical through the enclosure and can be from either the bottom or top. For rooms containing equipment with downward airflow, the air supply should be overhead and the return plenum should be low or in the floor. If a raised floor is in place, the space under the floor may provide the return plenum. For upward airflow, the use of the sub floor space as a supply plenum should consider the additional design considerations and continuing maintenance to prevent the infiltration and accumulation of dust, dirt, and moisture under the floor.

C. Relative Humidity: The selection of equipment shall consider the relative humidity to which I&C equipment may be exposed in the application. If necessary, the design shall incorporate the use of humidity control equipment to assure operation within the defined limits for the selected equipment.

Guidance: The operating relative humidity requirement for equipment is normally well defined in the manufacturer's literature and typically given as an operating range and a maximum time rate of change. Limitations may be given for shipping and storage as well as for operation. Typically, the desired operating range is about 40 – 60 percent. Low relative humidity (less than 30 – 40 percent) can result in system errors or shutdowns due to generation of static electricity. At LANL, this is addressed with proper grounding rather than humidification. High relative humidity can lead to condensation.

D. Particulate Contamination: The presence of particulate matter (dust or dirt) shall be considered for its affect on I&C equipment.

Guidance: Dust, grit, and sand present at the inlet of process media sensing devices can prevent the equipment from performing its function. Dust build-up decreases the ability of electrical components to shed their heat, which decreases longevity. In fan-cooled equipment, the accumulation of dust on filter media will reduce airflow and cause overheating. If the dust is conductive, it can cause faults: if nonconductive, it can infiltrate and insulate switches and contacts. Careful, meticulous sealing of all equipment enclosure openings will reduce contaminant infiltration.

E. Chemical Contamination: Consideration shall be given to potential chemical contamination and corrective action shall be taken to limit any potential contamination below levels that could adversely affect equipment performance.

Guidance: Certain chemicals, including sulfur dioxide, oxides of nitrogen, hydrogen sulfide, and ammonia, are known to affect electronic equipment at concentrations safe for human occupancy. Most corrosion processes accelerate rapidly at increased temperatures or humidity level (or both). Some maximum allowable levels recommended by equipment manufacturers are below levels that can be readily measured.

F. Vibration and Shock: The proposed location of I&C equipment shall be evaluated for potential sources of vibration and shock, such as nearby heavy rotating or stamping equipment or heavy mobile traffic. Consideration shall be given to potential vibration and shock sources when mounting I&C equipment to assure operation within the equipment manufacturer's defined limits.

Guidance: Continuous vibration can cause slow degradation of contacts and any mechanical parts. Shock can instantaneously change an instrument adjustment, as well as cause effects similar to vibration. It is usually more practical to relocate equipment or to apply controls at the vibrating equipment than to try to isolate the equipment from the vibration.

G. Power Line Conditioning and Backup: The equipment manufacturer's power requirements shall be met. In many cases, meeting these requirements involves more than just supplying the appropriate voltage and ampacity ratings. Frequently a special type of receptacle is required, which is usually well defined in the manufacturer's literature. Transient Suppressors may be required depending on the type of device. Tolerance to voltage transients and brownouts are also typically defined in the manufacturer's literature. ANSI standards permit user line voltage to be as much as 11.7 percent below nominal. Brownouts may cause additional voltage reductions of 3 to 10 percent. These reductions may severely disrupt equipment operations and may necessitate the need for power conditioning and/or backup power supplies.

Guidance: Certain critical systems should be able to operate through a power dip or an extended power outage; these should be provided with a backup power supply. For less critical systems, a packaged power conditioning system should be considered.

H. Electromagnetic Interference (EMI): The proposed location of I&C equipment shall be evaluated for potential sources of EMI and consideration shall be given to its effect on the operation of the equipment. EMI results from electromagnetic emissions generated by and coupled to equipment or systems (or both).

Guidance: Common EMI sources include thunderstorms, high voltage power lines, power tools and manufacturing machines, relays, contactors, motors, vehicle ignitions, and arc welders. Isolation, shielding, and grounding may be required to prevent expected problems.

I. Radio Frequency Interference (RFI): The proposed location of I&C equipment shall be evaluated for potential sources of RFI and consideration shall be given to its effect on the operation of the equipment. RFI results from electromagnetic fields generated by communication and electronic equipment.

Guidance: Common RFI sources include hand held radio transmitters, cell phones, proximity to radio or television disks or towers, and proximity to communication relay disks or towers. Generally, RF fields within the facility should not exceed 0.5 v/m. Not more than 1V RMS, in the frequency range of 10kHz to 3 MHz, should exist on the ac connection points to the system. Isolation, shielding, and grounding may be required to prevent expected problems.

J. Static Electricity: The potential for static electricity problems shall be determined and if present, prevented or corrected.

Guidance: Static electricity can have a significant affect on digital equipment and equipment connected to explosive applications or in explosive environments. The catastrophic effect is the breakdown and permanent damage of semiconductor devices. The transient effect is the introduction of extraneous logic signals or voltages induced on ground or signal wiring, which can result in operational error.

8.0 COMPUTER/CONTROL & DATA PROCESSING SYSTEMS AND EQUIPMENT (P & F)

8.1 General

A. The requirements and guidance identified within Section 7.0, Environmental Considerations, are applicable to computer/control and data processing systems and equipment. The following is provided as a supplement to Section 7.0 to specifically highlight the needs of digital and computer-based systems. When selecting a location for this type equipment, the environmental factors identified within this section shall be addressed.

Guidance: The following represents input and/or guidance in addition to that identified within Section 8.0, Environmental Considerations, for control/computer room design, equipment location, and equipment installation:

1. *Temperature: Although cooler temperatures are preferable for computers, operation near the center of the defined range is recommended to strike a balance between individual comfort, energy efficiency and computer operation.*
2. *Temperature: For rotating media storage (e.g., disk drives), the manufacturer typically gives a maximum allowable rate of temperature change. In such equipment, the disk and drive mechanism should be kept at the same operating temperature and rapid temperature transients should be avoided. This is true for most all I&C signal processing equipment.*
3. *Relative Humidity: Magnetic storage media should not be contained within areas that could experience rapid changes in relative humidity. The manufacturer of such equipment typically identifies the maximum allowable time rate of change.*

4. *Particulate and Chemical Contamination: Computer/control and data processing equipment, especially moving magnetic storage devices (disk drives and tapes), is typically sensitive to damage caused by contaminant infiltration. Filter replacement and dust or particulate removal should be performed regularly in all computer equipment cabinets as part of a preventative maintenance program. General cleanliness and good housekeeping practices should be enforced. Equipment and partitions should be arranged to minimize the number of times doors are opened. The use of the room as a thoroughfare should be prohibited. In some installations, a remote console will solve contaminant infiltration problems.*

5. *Vibration: Careful attention should be given to potential sources of vibration when selecting a location for disk drives, which are particularly sensitive to vibration effects.*

6. *Electrical Power: Design provisions or operating procedures (or both) should be established to prevent vacuum cleaner or similar motor driven equipment from being powered from the computer power conditioning system. Refer to ESM, Chapter 7 requirements for isolated ground power for computer and instrumentation loads. A disconnecting means should be provided to disconnect the power to all electronic equipment in a data processing room. This disconnecting device should be controlled from locations readily accessible to the operator at the principal exit doors. There should also be a similar device to disconnect the HVAC system servicing the area. Article 645 of the National Electrical Code provides specific requirements for the electrical wiring associated with computer systems.*

7. *Interference: A computer and peripherals can erroneously interpret radiated energy from EMI or RFI sources as data or control signals. The result can appear as I/O problems, analog to digital conversion inaccuracies, or outright processor failures. The random nature of the interference makes failure diagnosis difficult. Computer/control and data processing equipment should be located away from sources of EMI or RFI. When this is not practical, it may be necessary to enclose vulnerable computer components within an RFI-shielded enclosure or area.*

8.2 Computer/Control Rooms

A. The following items shall be addressed in the design of computer/control rooms:[10]

1. Proper space allocation for computer equipment, consoles, storage area (for manual, documents, listings, maintenance equipment, etc.), environmental conditioning equipment (air and electrical power conditioning), fire protection equipment, and power distribution.

2. Room accessibility for both operating and maintenance personnel. *Guidance: The addition of interior windows, where appropriate, can reduce unnecessary traffic (e.g., room security, safety of personnel, etc. can be observed without entering the room).*

3. Space allocation for any potential expansion.

[10] From NRC NUREG-0700, "Human-System Interface Design Review Guidelines," and IEEE-1023, "IEEE Guide for the Application of Human Factors Engineering to Systems, Equipment, and Facilities of Nuclear Power Generating Stations." DOE G 420.1-1, Section 3.6, identifies these standards as recommended sources for Human Factors Engineering principles and criteria. IEEE-1023 preferred over MIL-STD-1472D.

4. Suitable access and easy loading areas for equipment.
5. Adequate and convenient wire paths for installing signal, data, process control, safety, and associated power wiring to and from the computing systems. *Guidance: An overhead cable tray system provides the most convenient method for the installation of computer room wiring. Unrelated services, such as power conductors, water and steam piping, etc., should not be installed in the computer room or its included spaces and specifically should not be present overhead of data processing equipment or computer/control rooms. If unrelated services must be installed, the design should incorporate appropriate measures to protect the computer equipment.*
6. Data handling and analysis area. This is normally a small area for a conference table and chairs where computer printouts and reports may be laid out for analysis.
7. Emergency lights, fire doors, power and air handling interlocks, etc.
8. Radio Frequency Interference (RFI) and Electromagnetic Interference (EMI) shielding, if required.
9. Fire codes and requirements.
10. Telephone and intercommunication systems.
11. Adequate and proper lighting. *Guidance: Two levels of lighting may be necessary; one for normal operation and one for maintenance. The Illuminating Engineering Society (IES) Lighting Handbook includes both quantitative and qualitative design data for various lighting needs. Where CRTs are in use, glare and reflection should be eliminated, so indirect lighting should be used where possible. Dimmer switches are sometimes used to reduce glare. Note, however, that SCR dimmer controls can be a source of RFI and should be avoided.*

B. The computer/control room design, location, and access points shall be evaluated for the potential presence or introduction of contaminants through materials of construction, ventilation systems, transfer from adjacent areas or from workers and visitors. Any potential source of contamination that would affect the proper operation or reliability of the equipment shall be prevented by design, protective measures, or administrative procedures.[11]

Guidance: The following should be taken into consideration to prevent the presence or introduction of contaminates within a computer/control room:

1. *Only materials that do not produce contaminants should be used in control/computer room construction. Sprayed-on acoustical ceiling and mineral-based drooped ceiling tiles should be avoided because they tend to flake. Glass fiber tiles that produce abrasive particles and floor covering that tend to crack or crumble should be avoided. Also, carpets should be of a quality that minimizes the release fibers and particulate. All exposed concrete should be sealed.*
2. *Specially treated (impregnated) mats should be placed at each entrance to reduce the amount of dust tracked in by personnel.*

[11] Established from NRC NUREG-0700, "Human-System Interface Design Review Guidelines," Section 13.1.5 – Protecting Equipment and Components from Hazards.

3. *The use of a computer/control room as a gathering place should be avoided. However, the room may need to be used as a rally point for personnel in the event of a fire, explosion, or fume release. In such cases, provisions necessary for employee protection as well as for equipment protection should be considered.*
4. *All floor or other cable trays should be capable of being kept clean and free of dirt, grit, or debris.*
5. *Maintaining the computer/control room at a positive pressure may be considered as a means of preventing the entry of contaminates. In this application, special attention must be given to the quality of the inlet air and its source.*

C. The potential for static electricity in computer/control rooms shall be eliminated to the maximum extent possible in room design and equipment location. Where a potential may exist for the generation of static electricity that could be detrimental to equipment operation, measures shall be taken to minimize the potential for static electricity generation. This may take the form of material and equipment prohibitions, temperature and humidity control, grounding methods, etc.[12]

Guidance: The following should be taken into consideration to prevent static electricity in computer/control rooms:

1. *For control of static electricity, carpet is not the preferred floor covering for computer/control rooms. If carpet is used, steps should be taken to reduce static buildup. Certain carpets are given anti-static properties by the incorporation of metallic fibers during manufacture or treatment with anti-static agents. Anti-static sprays are available for use on existing carpet. Wax buildup on tile floors also increases surface resistivity and leads to static problems. The remedy is to forego waxing or to use a wax formulated for high conductivity.*
2. *Furniture in the vicinity of digital equipment should be chosen carefully. Seat covers of plastic are normally more likely to generate static charges than cloth covers. Wheels and casters should contain conductive material and should be lubricated with graphite or conductive grease. Rubber or plastic feet should be avoided.*
3. *Storage space may be required for operating supplies and storage media, spare parts and components, and backup software. These items may need protection from static electricity buildup both in storage and when handled. The manufacturer's recommendations for both the use and storage of these items should be followed.*
4. *Personnel grounding straps and insulating footpads may be necessary for especially sensitive processes or operations. Equipment sensitivity of this nature should be identified in design and operation documentation.*

D. *Guidance: Locating a computer/control room in an area subject to flooding should be avoided. Where this is not realistic for all possible conditions and flooding is possible, alternative measures should be taken, such as constructing a raised floor for the computer/control room. For raised-floor computer/control rooms, the installation of an alarm system initiated by water detectors located under the raised flow should be considered.*

[12] Established from NUREG-0700, "Human-System Interface Design Review Guidelines," Section 13.1.5 – Protecting Equipment and Components from Hazards.

9.0 COLOR CONVENTIONS FOR PROCESS DISPLAYS[13] (P & F)

A. Within a given facility, color conventions for process displays shall be consistent, simple, and unambiguous.

B. Color coding shall be redundant with some other display feature (e.g., text, symbol, shape, size, intensity, or inverse video) such that all necessary information is available on a monochromatic display or printout, or when viewed by a user with color vision impairment.

C. The color conventions given in the following Table shall be used for process displays.[14] Guidance: Color identified in the last column as "Contrasts Well With" are recommendations, not requirements. However, color combinations should be carefully selected to ensure good contrast (i.e., do not use red characters on a green background).

[13] Taken from SRS Engineering Standards Manual WSRC-TM-95-1, "Color Conventions for Process Displays," in accordance with ANSI / ISA 5.5-1985, "Graphic Symbols for Process Displays."

[14] The color convention table is taken from NRC NUREG-0700, 1997, , Rev. 2, Table 1.4, "Guidelines for Control Room Design Reviews," and ANSI / ISA 5.5-1985, "Graphic Symbols for Process Displays."

Table 10-1
Color Conventions for Process Displays

Color	Generic Meaning	Associated Meanings	Attention Getting Value	Contrasts Well With
Red	Unsafe	Emergency Danger High Priority Alarm Closed / Off / Stopped (inactive) Closed / On / Flowing (electrical power distribution)	Good	White
Yellow	Caution	Hazard Second Priority Alarm Abnormal State	Good	Black Dark Blue
Green	Safe	Safe Satisfactory Open / On / Flowing (active) Open / Off / Stopped (electrical power distribution)	Poor	White
Light Blue (cyan)	Static and Significant	Equipment in Service Major Labels	Poor	Black
Dark Blue	Non Essential	Equipment in Standby Labels, Tags	Poor	White
Magenta	Radiation	Radiation Alarm / Caution Questionable Values	Good	White
White	Dynamic Data	Measurement and State Information System Messages Trend Active Sequence Step	Poor	Black Green Dark Blue Magenta Red
Black	Background		Poor	White Yellow Light Blue

D. For ML-2/Safety Significant or ML-1/Safety Class structures, systems and components, a review shall be conducted during the design process for proper application of color and shape conventions from a human factors perspective.

E. *Guidance: The number of colors used for coding should be kept to the minimum needed for providing sufficient information (usually no more than eight colors). Decorative use of color should be eliminated.*

F. *Guidance: Highly saturated colors should be used for coding to provide good contrast from each other and their backgrounds.*

G. *Guidance: Gradual changes in color intensity should not be used to indicate relative values of variables.*

H. *Guidance: Flashing or audible indications should be included when display items require immediate operator attention, such as alarms.*

10.0 GROUNDING PRACTICES (P&F)

A. Grounding systems for I&C and Computer/Data Processing systems and equipment shall be provided to minimize damage to equipment, interference with equipment operation or signal processing, and shock or other electrical hazards to personnel. Federal Information Processing (FIPS) Pub 94 provides a guide, checklist and evaluation criteria for specifying power and related grounding and life-safety requirements for the design, installation, and operation of Automatic Data Processing (ADP) systems. This standard shall be used in conjunction with the mandatory power-grounding requirements of NFPA 70 - Article 250, IEEE 142, IEEE 1100, and IEEE 1050.

Guidance: Grounding systems should be designed to meet the following major goals:

1. *Provide for personnel and equipment protection and life-safety required by various regulatory agencies.*
2. *Maintain all equipment and circuits at the same reference ground potential.*
3. *Provide a safe, high ampacity fault return path for those power distribution systems that have the source or generating system referenced to ground.*
4. *Maintain a low inductive loop area between the power distribution system and the fault return path for equipment that has a potential for high fault currents.*
5. *Provide a low impedance leakage path for any static charge that may accumulate on equipment.*
6. *Provide a low impedance discharge path for energy storage devices such as capacitors and inductors that are installed for the suppression of high voltage transients or electrical noise.*
7. *Minimize noise interference in instrumentation systems by providing common reference planes of low relative impedance between devices, circuits, and systems.*
8. *Assure that all ground system conductors that must carry high frequency signals (greater than 10 kHz) are selected for low inductance characteristics. At 1 Megahertz, the impedance of an average length ground conductor is around 4,000 ohms.*

B. Conductive enclosures that contain I&C and computer/data processing system components shall be appropriately connected to ground to ensure that shock hazard risks are minimized for personnel.[15]

Guidance: The connection should provide a low resistance path to ground for any fault currents that may be produced by mechanical failures, insulation failures, component failures, accidents, etc. Low resistance paths to ground maintain low potential differences between metal components and reduce the chances of a fault-induced current flowing through personnel in contact with system components. Grounding is especially important in an environment where conductive elements may be present in the flooring, piping, ductwork, or other equipment.

[15] Established from NFPA 70, Article 250 – Grounding, Section 250.4 and IEEE 1050, "Guide for Instrumentation and Control Equipment Grounding in Generating Stations," Section 5.0 – I&C System Grounding.

C. The grounding of I&C and computer/data processing systems shall provide protection against self or adjacent equipment generated or induced electrical noise.

Guidance: The following information provides insight on potential sources of electrical noise, its effects on I&C and/or computer/data processing systems, and the application of proper corrective grounding techniques:

1. Computer/control and data processing systems utilize high speed, low level switched signals for operation. At the high frequencies at which these systems operate, electrical noise will propagate, traveling between two conductors or between an insulated ground conductor and other grounds or metallic components in the area. It is important that the system ground be connected in such a way that it does not act as part of a transmission line to couple noise into the computer system. This can be avoided by keeping this ground very short, tying directly to the reference ground plane or ground node, or by insuring that only one conductor is connected to the system and all other signals enter on fiber optics.
2. *Noise can be avoided by segregating equipment that generates electrical noise from computer circuitry. Relatively small amounts of high frequency electrical noise can disrupt computer operation and cause downtime, loss of function, or spurious equipment operations.*
3. *When using LAN's, such as Ethernet, and low frequency noise is encountered, the loop may be broken by installing ground isolation devices in the communication network at each node. The ground isolation device will appear as a high pass filter inserted in the communication link. Ensure ground isolation of the communications network at each node.*
4. *All connections in signal cable should consider possible noise coupling points and should be made carefully with special consideration given to the shield connection. Anytime the shield of a coax cable is broken a coupling path is created for high frequency noise from the outside environment to enter the inside environment of the coax cable shield.*
5. *The biggest contributor to signal inaccuracy is noise injected into input/output signals. The best way to minimize this noise is through proper grounding and wiring methods of the I/O signal hook-up. IEEE Standard 1050 should be used as a reference on shielding and grounding for instrumentation cables.*

D. For control and computer/data processing communications protocols that utilize non-isolated systems to transfer data (RS232, RS422, RS423, etc.), the Data Terminal and Communication equipment shall be powered and grounded by the same source as the device providing the signal to prevent ground loops. Peripherals connected to optically isolated communications can be grounded to any grounding system of adequate integrity.[16]

[16] Established from IEEE 1100, "IEEE Recommended Practice for Powering and Grounding Electronic Equipment," Chapter 9 – Telecommunications and Distributed Computing, Section 9.11.2 – Grounding.

E. Facility grounding systems shall be evaluated to ensure the system is adequate for the applicable I&C and/or computer/data processing system and equipment.[17]

Guidance: Large inductive electrical loads cause electrical noise on all conductors in the vicinity and a typical facility ground may have loops that will pick up very large noise voltages. The inadvertent connection of a computer system across such a loop may couple large noise signals into the computer system. To avoid the inadvertent second connection to facility ground, it may be preferable to run a separate ground node for the computer system. This ground node should still tie to the facility ground at a single point for safety reasons. The facility ground system should be evaluated to determine if the network impedance is suitable for a proper ground system. If it is not, then it will be necessary to install a new ground system network that is connected to earth at the same point as the facility ground. Grounding methods should be in accordance with IEEE Standard 142, which complements the NEC.

F. For I&C and computer/data processing distributed systems, grounding conductor runs over 250 feet shall be avoided. If conductor runs over 250 feet are necessary, a new single point ground node shall be created for all equipment that is located within the 250 foot run limit and connected to the single point earth ground for the facility/system.[18]

Guidance: It is possible to treat different system nodes as essentially separate systems as far as grounding is concerned. This adheres to the distributed ground concept in IEEE 1050. Every effort should be made to ground equipment that may communicate in any way to the same earth ground. If more than one piece of equipment is tied to separate earth grounds, the earth currents will create a potential difference between the equipment. A lightning strike or power fault in the vicinity can create hazardous potentials between earth grounds. When distances from a system or equipment to the nearest node become excessive, a new node should be created.

***Note**: As the frequency increases, the impedance of the ground conductor increases. At 10 Megahertz, the impedance of a typical ground conductor may be in the order of 40,000 ohms and will no longer serve the purpose of providing a common reference point. Where high frequency grounds or connections are required, conductor shape and length must be selected for low inductance (impedance).*

[17] The requirement is deemed “Good Engineering Practice” and is established to ensure that the integrity of the facility grounding system is adequate for proper system operation. An inspection is considered necessary to ensure compliance with NFPA 70.

[18] The requirement is established to preclude the installation of a ground conductor that would not provide an effective low-impedance current signal reference. Refer to IEEE 1050, “Guide for Instrumentation and Control Equipment Grounding in Generating Stations,” Section 5.2.2 – Ground Conductor Lengths. For Single-point grounding refer to IEEE 1100, “IEEE Recommended Practice for Power and Grounding Electronic Equipment,” Chapter 8 – Grounding Consideration, Section 8.5.4.5 – Single-point and Multi-point Grounding.

G. *Guidance: The codes, standards and guidelines identified in this section provide grounding practices that should be consistent with most equipment manufacturer requirements. However, these codes, standards and guidelines should be used in conjunction with the manufacturer's computer control and data processing systems grounding recommendations. The manufacturer's grounding specifications should be reviewed for consistency with relevant standards and industry practices. Grounding schemes requiring a dedicated ground conductor routed separately to special earth points would not be acceptable. The I&C and/or computer/data processing system design and installation should be in compliance with the applicable portions of the National Electric Code. Safety takes precedence over potentially conflicting considerations.*

11.0 Additional Requirements for Safety-Related Systems (P & F)

Note: Refer to Section 2.0 for the definition of safety-related systems.

11.1 General

A. The codes and standards identified within the Task Matrix (Table 3-1) in Section 3.5 contains the minimum set of codes and standards that shall be applied to satisfy the requirements of DOE O 420.1B regarding safety-related instrumentation and control systems. Alternative methods can be used only if the requirements of this section are satisfied as determined by independent review and a variance is granted in accordance with ESM Chapter 1 Section Z10. Any implementation methods selected must be justified and documented to ensure that an adequate level of safety commensurate with the identified hazards is achieved.[19]

B. Emergency features shall be provided to include alarms and monitors that alert workers and the public to the existence of unsafe conditions and to record the sequence and severity of an accident.[20]

C. Alarms for loss of ventilation or differential pressure shall be provided on primary confinement systems (gloveboxes or hoods).[21] *Guidance: Alarms for loss of ventilation or differential pressure should also be considered on secondary confinement systems (rooms).*

D. The requirements from 29 CFR 1910, Subpart Z, shall be addressed for monitoring and alarms systems for facilities that manage or use specific hazardous materials.[22]

E. Alarms shall be provided to annunciate in the event concentrations of radioactive or hazardous materials above specified limit are detected in an effluent stream.[23]

F. Adequate instrumentation and controls must be provided to assess system performance and to allow the necessary control of system operation.[24]

[19] For compliance with DOE O 420.1B.
[20] From DOE G 420.1-1, Section 2.3 – Defense in Depth.
[21] From DOE G 420.1-1, Section 4.2.3 – Special Considerations and Good Engineering Practices.
[22] From DOE G 420.1-1, Section 4.3.2 and 4.3.3 – General Application.
[23] From DOE G 420.1-1, Section 4.4.2 – Special Considerations and Good Engineering Practices.
[24] From DOE G 420.1-1, Section 4.4.2 – Special Considerations and Good Engineering Practices.

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G. General communication system installation requirements must be in accordance with NFPA 72, Sections 3-12, 6-3 and 6-4. Section 3-12 describes the minimum requirements for transmission of alarm conditions to building occupants, and Section 6-3 and 6-4 include minimum requirements for audibility above background noise and the use of visual signals, including minimum light intensities.[25]

H. The safety functions of instrumentation, control, and alarm systems shall:[26]

1. Provide information on out-of-tolerance conditions/abnormal conditions
2. Ensure the capability for manual or automatic actuation of safety systems and components
3. Ensure safety systems have the means to achieve and maintain a fail-safe shutdown condition on demand under normal and abnormal conditions, actuate alarms to reduce public or site-personnel risk, and inform operators of safety actions required and completed (e.g., effluent monitoring components and system).

I. The design of safety-related instrumentation and control systems must incorporate sufficient independence, redundancy, diversity, and separation to ensure that all safety-related functions associated with such equipment can be performed under postulated accident conditions as identified in the safety analysis. Under all circumstances, ML-1/safety-class instrumentation, controls, and alarms must be designed so that failure of non-safety equipment will not prevent the former from performing their safety functions.[27] *Guidance: Safety-significant components should be evaluated as to the need for redundancy on a case-by-case basis*

J. Safety-related instrumentation and alarm-system designs must ensure accessibility for inspection, maintenance, calibration, repair, or replacement.[28]

K. Safety-related instrumentation, control, and alarm systems must provide the operators sufficient time, information, and control capabilities to perform the following safety functions:[29]

1. Readily determine the status of critical facility parameters to ensure compliance with the limits specified in the Technical Safety Requirements.
2. Initiate and verify completion of manual safety functions or verify automatic action is initiated and completed.
3. Determine the status of safety systems required to ensure proper prevention of the accident or mitigation of the consequences of postulated accident conditions and/or to safely shut down the facility.

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[25] From DOE G 420.1-1, Section 4.7.3 – General Application. ANSI N2.3, Evacuation Alarm Systems, listed in DOE G 420.1-1, was withdrawn.
[26] From DOE G 420.1-1, Section 5.2.4 – Instrumentation, Control, and Alarm Systems. Safe shutdown from 5.1.1.4.
[27] From DOE G 420.1-1, Section 5.2.4 – Instrumentation, Control, and Alarm Systems.
[28] From DOE G 420.1-1, Section 5.2.4 – Instrumentation, Control, and Alarm Systems.
[29] From DOE G 420.1-1, Section 5.2.4 – Instrumentation, Control, and Alarm Systems.

L. Safety-related ventilation system designs must provide manual or automatic protective control features as needed to prevent or mitigate an uncontrolled release of radioactive and/or hazardous material to the environment and to minimize the spread of contamination within the facility. Also, inclusion of adequate instrumentation to monitor and assess performance with necessary alarms for annunciation of abnormal or unacceptable operation is required.[30]

M. Appendix E, Alarm Management Guidance shall be considered requirements for safety related instrumentation systems. However, the I&C POC shall have authority to grant variance to these requirements.

N. *Guidance: The preferred method to prevent or mitigate a safety basis event is to provide automatic protective features with appropriate alarms to indicate the approach to actuation of the automatic feature and monitoring devices to provide accurate indication of the sensed parameter value, etc.*

O. ML levels and SS and SC are discussed in ISD 341-1, *Engineering Processes Manual*, and AP-341-502, *Management Level Determination for Structures, System, and Components*.

11.2 Installation of Safety-Related Systems [31]

A. Installations shall conform to instrument location, installation and isometric (if provided) drawings. These documents shall establish the installation design requirements for ML-1 and/or Safety Class and ML-2 and/or Safety Significant instruments and their sensing lines, with regard to their safety function, postulated health hazard and their protection against failure.[32]

B. ML-1/Safety Class redundant instruments, instrument tubing, and piping (sensing lines) shall be routed and/or protected to withstand the credible effects both during and following design bases accidents for which the instruments/systems are required to perform.[33]

C. Separation of redundant ML-1/Safety Class or redundant (as determined by safety analysis) ML-2/Safety Significant instrument shall be achieved by the use of structures, distance, barriers, or any combination thereof. Any deviation from these methods of separation must be submitted to the I&C POC for approval.[34]

D. For technical requirements for safety-related tubing and piping systems, see Mechanical Chapter 6.

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[30] From DOE G 420.1-1, Section 5.2.2.1 – Ventilation.
[31] Taken from SRS Engineering Manual WSRC-TM-95-58, "Mechanical Installation of Safety Class and Safety Significant Instrumentation," for compliance with DOE Order 420.1A.
[32] IEEE 336, "IEEE Standard Installation, Inspection, and Testing Requirements for Power, Instrumentation, and Control Equipment at Nuclear Facilities."
[33] IEEE 384, "IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits."
[34] IEEE 384, "IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits."

E. Redundant ML-1/Safety Class and redundant (as determined by safety analysis) ML-2/Safety Significant instrument sensing lines shall be routed and protected so that the failure of one redundant system will not disable equipment essential to the operation of the other redundant system(s). Sensing lines of one channel shall not crossover or come in contact with equipment of another redundant channel, whether it is in the same or another functional loop of another channel.[35]

F. Safety-related wiring, sensing lines, and mechanical signal lines shall not be routed where vibration, abnormal heat, or stress could affect performance.[36]

G. When locating safety instruments on racks or in cabinets, care must be given to assure that no two redundant instruments are mounted on the same rack or in the same cabinet.[37]

H. The minimum separation between instrument sensing lines of redundant channels shall be at least 46 cm (18 inches) in air in both horizontal and vertical directions in non-missile or jet impingement areas. The 46 cm (18 inches) minimum spacing required between the redundant channels shall be maintained from its starting point at the root valve to the vicinity of the instrument. If this separation is not possible, Engineering shall be consulted to determine if a suitable barrier should be used. A barrier may be equipment, structural steel shapes, building structures such as walls, ceilings, floors and shield walls. When a barrier is used, it shall extend at least 2.5 cm (1 inch) beyond the line of sight between the two redundant channel sensing lines. Where potential missiles can be identified, additional separation, barriers and/or missile shields may be necessary. Missile shields may be structural steel shapes such as plate, channel and angle, covered tray or pipe guards.[38]

I. Supports, brackets, clips or hangers shall not be fastened to the sensing lines or their supports for the purpose of supporting other equipment, cables, etc., without specific approval.[39]

J. Where instrument sensing lines of more than one channel of a redundant set penetrate a wall or floor, the redundant sensing lines shall be routed through separate penetrations and separated by a minimum distance of 46 cm (18 inches). If the use of separate penetrations is not feasible, approval is required to use a common penetration. The use of a common penetration may require the design of:[40]

   1. A suitable barrier, such as a guard pipe, to protect instrument sensing lines in one channel or division from postulated effects of a failure of the other channels or divisions.

[35] IEEE 384, "IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits."
[36] ISA 67.02.01, "Nuclear Safety-Related Instrument Sensing Line Piping and Tubing Standard for Use in Nuclear Power Plants."
[37] IEEE 384, "IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits."
[38] ISA 67.01.01, "Transducer and Transmitter Installation for Nuclear Safety Applications."
[39] ISA 67.02.01, "Nuclear Safety-Related Instrument Sensing Line Piping and Tubing Standard for Use in Nuclear Power Plants."
[40] ISA 67.01.01, "Transducer and Transmitter Installation for Nuclear Safety Applications," and ISA 67.02.01, "Nuclear Safety-Related Instrument Sensing Line Piping and Tubing Standard for Use in Nuclear Power Plants."

2. A missile shield, to be installed around the lines until a minimum separation distance of 46 cm (18 inches) is achieved between the different redundant sensing lines.

K. Instrumentation and sensing lines shall be easily identified and distinctly labeled as ML-1/Safety Class or ML-2/Safety Significant. Each instrument sensing line, as a minimum, shall be tagged at its process line root valve connection, at the instrument, and at any point in between where the sensing line passes through a wall or a floor (on both sides of such penetrations).[41]

L. Barriers used to protect instrumentation (as determined by safety analysis) shall be identified in the field, to prevent inadvertent degradation of this protection.[42]

M. To prevent the loss of both parts of a redundant set of instruments, separate process pipe connections with sufficient separation shall be used wherever possible.[43]

1. When a single process connection must be used, the system shall be designed for a "safe" trip action of the channel upon tap or sensing line breakage.
2. The single process connection shall be protected from credible sources of damage and separation of the redundant sensing lines shall be achieved as close as possible to the process connection.

11.3 Application of ISA 84.01-1996 for LANL Non-Reactor Facilities[44]

A. ANSI/ISA 84.01-1996 shall be applied in the design, installation and testing of nuclear Safety Significant instrumented systems and non-nuclear instrumented systems that would be considered SS using the definition in Section 2.0. The standard shall also be applied to ML-2 instrumented systems that have an impact on safety. The following constitute specific clarifications, modifications, substitutions, additions, or deletions to the identified sections of ISA 84.01-1996, for use in LANL non-reactor facilities. Those not specifically referenced are deemed appropriate as written, except for word substitutions.

[41] ISA 67.02.01, "Nuclear Safety-Related Instrument Sensing Line Piping and Tubing Standard for Use in Nuclear Power Plants."
[42] ISA 67.01.01, "Transducer and Transmitter Installation for Nuclear Safety Applications."
[43] ISA 67.02.01, "Nuclear Safety-Related Instrument Sensing Line Piping and Tubing Standard for Use in Nuclear Power Plants."

[44] The standard for the design, installation, operation, maintenance, start up and periodic functional testing and management of safety instrumented systems. The standard promotes a risk-informed performance-based methodology for the life cycle management of safety systems. The methodology was applied at SRS to provide a graded approach to the design of Safety Significant Instrumented Systems (SSISs) in non-reactor nuclear process facilities, based on the unmitigated risk (consequence and frequency) of the safety significant event. (Reference: WSRC-MS-2001-00404 Rev 0, "Implementing ISA S84.01-1996 at a Department of Energy Site, Sossman and Suttinger").

The application of ISA 84.01-1996 is a result of several reviews conducted by the Defense Nuclear Facilities Safety Board (DNFSB) of safety significant instrumentation and control systems. These reviews found that some systems did not meet industry standards for reliability. DNFSB letters dated February 7, 2000 and March 30, 2000 addressed these problems and identified the ISA 84.01-1996 standard for use by DOE as a design guideline for safety significant instrumented systems. Per the recommendation of the DNFSB, this standard has been adopted at several DOE sites. (Reference: Defense Nuclear Facilities Safety Board Eleventh Annual Report to Congress, February 2001).

B. Word Substitutions:

1. "Safety Significant Instrumented System" is substituted for "Safety Instrumented System" in ISA 84.01-1996.
2. "SSIS" is substituted for "SIS" in ISA 84.01-1996.
3. "Facility is substituted for "unit" in ISA 84.01-1996.

C. The first sentence of ISA 84.01-1996, Scope Clause 1, is revised as follows to clarify that the standard is applicable to Safety Significant or hazardous process systems in LANL non-reactor facilities:

"This standard addresses Electrical/Electronic/Programmable Electronic Systems (E/E/PES), associated sensors, logic devices, final elements, and interfaces used in LANL non-reactor nuclear and non-nuclear facilities with Safety Significant/ML-2 SSCs or 29 CFR 1910.119 designated process safety instrumented systems."

D. ISA 84.01-1996, Section 1.2 Exclusions, Item 1.2.4, is revised as follows to clarify that the standard is applicable to non-reactor facilities:

"This standard does not address the codes, regulations, and other requirements that apply only to the Nuclear Power Industry."

E. ISA 84.01-1996, Section 1.2 Exclusions, Item 1.2.14, is deleted since operation action, as part of a SSIS, would be covered by the standard when operator action is justified by qualification and training and there is sufficient time for the operator to respond to an alarm.

F. ISA 84.01-1996, Section 2.2 Existing systems, is deleted. The Code of Record governs the design of existing facilities. When modifications are made the engineer/designer determines whether to use the existing Code of Record or current codes and standards. The Code of Record governs the design for the replacement SSCs.

G. The following acronyms shall be added to ISA 84.01-1996, Section 3.2 Acronyms:

1. SSC: Systems, Structures and Components
2. SSIS: Safety Significant Instrumented System

H. ISA 84.01-1996, Section 8.0 shall be implemented using LANL policies and procedures for the subject areas of Installation, Commissioning and Pre-Startup acceptance test.

11.4 Application of IEEE 384-1992 for LANL Non-Reactor Facilities [45]

A. IEEE 384-1992 shall be used to satisfy the requirements of DOE O 420.1B unless an alternative method is justified in the Design Documents. The requirements of IEEE 384 shall[46] be strictly applied to the design of SC/ML-1 instrumented systems and the associated interfaces unless a variance is granted in accordance to Chapter 1, Section Z10. The following constitute specific clarifications, modifications, substitutions, additions, or deletions to the identified sections of the standard, for use in LANL non-reactor facilities. Those not specifically referenced are deemed appropriate as written, except for word substitutions.

B. Word Substitutions:

1. "Control room" is substituted for "main control room" and/or "central control room" in IEEE 384-1992, since a control room in a non-reactor facility serves the same function as the main control room in a nuclear power generating station.
2. "Emergency" is substituted for "Standby" in IEEE 384-1992.
3. "Facility is substituted for "unit" and/or "station" in IEEE 384-1992.
4. "Non-reactor facility" is substituted for "nuclear power generating station" in IEEE 384-1992.

C. IEEE 384-1992, Section 2 Purpose, is revised as follows to add DOE Order 420.1B, since the order defines the facility design criteria:

"This standard establishes the guidance for implementation of the independence criteria of DOE Order 420.1B, IEEE 603 and IEEE Std 308-1991. In addition, this standard provides criteria for implementation of independence requirements for safe shutdown systems."

D. *Guidance: IEEE 384-1992, Section 3 References, has a list of other standards that are to be used with IEEE 384-1992. All standards referenced by IEEE 384-1992 should be used only as information to be considered during the design of a facility or a project.*

E. The following applies to IEEE 384-1992, Section 4 Definitions:

1. The definition of "Class 1E" is deleted from the section.
2. The definition of "emergency power" is added as follows to replace "standby power", since the term "standby power" as it applies to LANL non-reactor facilities is used to supply non-safety systems as described in NFPA 70, NFPA 110, and IEEE 446:

   "The power supply that is provided to ML-1/Safety Class equipment and/or ML-1/Safety Class systems to allow them to maintain their safety functions during periods of partial or total failure of the preferred power system."

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[45] Provides an interpretation of how IEEE 384-1992, "IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits," should be applied within DOE non-reactor facilities in order to implement DOE G 420.1-1 as a safe-harbor methodology for compliance with DOE O 420.1B.

[46] Lessons learned from TA-18 ITMS Project [EM-Ref. 49]

Deleted: A

3. The definition of "exposure fire" is added as follows from 10 CFR 50, Attachment R, to clarify the independence requirements for safety shutdown systems that have been added as criteria:

   "A fire in a given area that involves either in situ or transient combustibles and is external to any structures, systems or components located in or adjacent to that same area. The effects of such fire (e.g., smoke, heat, or ignition) can adversely affect those structures, systems, or components important to safety."

4. The definition of "safe shutdown" is added as follows to establish the meaning of safe shutdown for a non-reactor nuclear facility:

   "Safe shutdown in a non-reactor nuclear facility is a shutdown of a process with (1) the reactivity (nuclear or chemical) of the process kept to a margin below criticality (prevent accidental nuclear criticality) consistent with the facility technical specifications, (2) systems, structures, and components necessary to maintain this condition operating within their design limits, and (3) components and systems necessary to keep offsite doses within prescribed limits operating properly."

F. The following applies to IEEE 384-1992, Section 5 General Independence Criteria:

1. The "Note" at the end of Section 5.5.2, Criteria (Associated Circuits), is revised as follows to delete the reference to unit generators:

   "Preferred power supply circuits from the transmission network that become associated circuits solely by their connection to the ML-1/Safety Class distribution system input terminals are exempt from the requirements for associated circuits."

2. The following sentence is added to Section 5.10.2, Fire, to provide a clarification of fire protection for ML-1/Safety Class systems to prevent the over design of ML-1/Safety Class systems that are not required for safe shutdown:

   "ML-1/Safety Class systems, not located in fire hazard areas, used to mitigate the consequences of design basis events but not required for safe shutdown, may be lost to a single exposure fire."

G. The following applies to IEEE 384-1992, Section 6 Specific Separation Criteria:

1. The following Note is added to the end of Section 6.1.1.2, Minimum Separation Distances (Cable and Raceways). The reduced separation allowed by considering the identified types of cables as enclosed conduit for instrument and control cables has been approved and used in the commercial nuclear industry.

   "Mineral Insulated (MI) and Aluminum Sheathed (ALS) cable can be considered as enclosed raceways for instrument and control cables only."

2. The term "standby generating unit" is substituted with the term "emergency generating unit" wherever it is used in Section 6.2, Standby Power Supply, to stay consistent with the general substitution of "emergency" for "standby".

H. The following represents additional content added to IEEE 384-1992, Section 7.2, under the Heading, “Non-Safety Class Power Supplying ML-1/Safety Class Equipment”.

1. Electrical isolation of Non-Safety Class power circuits from ML-1/Safety Class components should be achieved by ML-1/Safety Class isolation devices applied to interconnections of the Non-Safety Class power circuits and the ML-1/Safety Class component/function (See Fig. 9 of IEEE 384-1992).

2. Sections 7.1.2 and 7.2.2 of IEEE 384-1992 provide general information for protective devices for this particular type of interconnection.

   However, for this interconnection a device is considered an electrical isolation device for power, and instrumentation and control circuits if it is applied so that (a) the maximum credible voltage or current transient applied to the device’s ML-1/Safety Class side will not degrade the operation of the circuit connected to the device’s non-safety side below an acceptable level; and (b) shorts, grounds, or open circuits occurring in the ML-1/Safety Class side will not degrade the circuit connected to the device’s non-safety side below an acceptable level.

   The highest voltage to which the isolation device ML-1/Safety Class side is exposed should determine the minimum voltage level that the device should withstand across the ML-1/Safety Class side terminals, and between the ML-1/Safety Class side terminals and ground. Transient voltages that may appear in the ML-1/Safety Class and Non-Safety Class sides must also be considered.

   The separation of the wiring at the input and output terminals of the isolation device may be less than 1 in (2.5 cm) as required in 6.6.2 of IEEE 384-1992 provided that it is not less than the distance between input and output terminals.

   Minimum separation requirements do not apply for wiring and components within the isolation device; however, separation should be provided wherever practicable.

   The capability of the device to perform its isolation function should be demonstrated by qualification test. The test should consider the levels and duration of the fault current on the ML-1/Safety Class side.

3. When the requirements of Items 1 and 2 above are met, the following devices may be used as acceptable isolation devices for instrumentation and control circuits:

   a. Amplifiers
   b. Control switches
   c. Current transformers
   d. Fiber optic couplers
   e. Photo-optical couplers
   f. Relays
   g. Transducers
   h. Power packs
   i. Circuit breakers
   j. Input current limiters

   Note: In using contact-to-contact isolation, consideration should be given to the effect on independence that may occur from welding of contact.

4. When the requirements of Items 1 and 2 above are met, a fuse may be used as an isolation device (except between redundant divisions) if the following additional criteria are met. The requirements have been developed because of the methodology used to classify a component or a component's function. A component may be classified as ML-1/Safety Class, but does not rely on electric power to perform its safety function. The electric power is present only for operational requirements. Therefore, the power may be obtained from a Non-Safety Class source if proper circuit protection is provided.
   a. Fuses should provide the design overcurrent protection capability for the life of the fuse.
   b. The fuse time-overcurrent trip characteristic for all circuit faults should cause the fuse to open prior to the initiation of an opening of any upstream interrupting device.
   c. The power source should supply the necessary fault current to ensure the proper coordination without loss of function of other Non-Safety loads.

I. The following represents additional content added to IEEE 384-1992, under the Section Heading, "ML-1/Safety Class Safe Shutdown Cables and Equipment".

1. General: ML-1/Safety Class safe shutdown cables and equipment should comply with the requirements of previous sections of this document and the following additional requirements.
2. The independence of redundant ML-1/Safety Class safe shutdown cables and equipment should be maintained for a single postulated exposure fire.
3. A single exposure fire should be postulated in those areas of the facility which contain cables or equipment necessary to provide safe shutdown capability in the event of fire.
4. An exposure fire should be postulated to occur regardless of whether or not the area contains ignition sources or combustible materials.
5. Exposure fires should not be postulated concurrent with non-fire related failures in ML-1/Safety Class systems, design basis events, or natural phenomena (for example, earthquakes, tornado).
6. The independence of ML-1/Safety Class safe shutdown systems, structures, and components should be such that a single postulated exposure fire should not defeat the safe shutdown function.
7. Redundant ML-1/Safety Class cables and equipment required for safe shutdown should be located in different fire areas. The area boundaries should meet the requirements of Section 6.1.8.2 of IEEE 384-1992.
8. When redundant safe shutdown cables and equipment are located within the same fire area, one of the following requirements must be met:
   a. Redundant ML-1/Safety Class cables and equipment required for safe shutdown should be separated from each other by a 3-hour fire barrier. Structural steel forming a part of or supporting such fire barriers should be protected to provide fire resistance equivalent to that required of the barrier.

b. Separation of cables and equipment of redundant divisions by a horizontal distance of more than 20 feet with no intervening combustibles or fire hazards. In addition, fire detectors and an automatic fire suppression system should be installed in the fire area.

c. Enclosure of cables and equipment of one redundant division in a fire barrier having a 1-hour rating. In addition fire detectors and an automatic fire suppression system should be installed in the fire area.