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NUCLEAR FACILITY EQUIPMENT DESIGN GUIDE - VOL 2 OF 2

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Exam Preview:

1. The fusion facility distribution system is primarily a high voltage system (35-115 kV) designed to supply the heavy (and often pulsed) loads for fusion facility operation
    a. True
    b. False
2. The facility distribution system generally consists of four types (IV, III, II and I) of power to supply those loads which are required to operate independently of the Fusion Facility Distribution System. Which type matches the description: Uninterruptible direct current (DC) supply for those loads requiring the most continuity of supply?
    a. Type IV
    b. Type III
    c. Type II
    d. Type I
3. The DC MCCs will be similar to the 480 VAC MCCs except that starters will be reduced-voltage type to limit the motor starting inrush current to 300% of rated current.
    a. True
    b. False
4. According to the reference material, which of the following is the preferred supply voltage for motors 1 to 250-hp?
    a. 13,800V, 3-phase, 60-Hz
    b. 480V, 3-phase, 60-Hz
    c. 4,160V, 3-phase, 60-Hz
    d. 120V, single phase, 60-Hz

5. Remote connector systems (sometimes referred to as "Hanford" type) can be used in the process piping as mechanical jumpers. This type of jumper system allows remote assembly and disassembly of mechanical components such as pumps, valves, pressure vessels, etc.
   a. True
   b. False
6. According to the reference material, a candidate for certification should receive an initial medical examination by a physician and should be reexamined at least every _ year(s) to verify health and physical fitness to perform assigned tasks safely.
   a. 5
   b. 3
   c. 2
   d. 1
7. For purpose of sizing the cable, it should be assumed that overload operation at the emergency temperature of the conductor will be limited to 100 hours per year, and that such 100-hour overload periods will not occur more than ___ times during the life of the facility.
   a. 2
   b. 5
   c. 10
   d. 15
8. Conductor size for control cables should be at least No. 10 AWG. Control cables between switchyard and plant area should be of the shielded type.
   a. True
   b. False
9. Using Table II-3. Load voltages for general-purpose starter, what size start would be needed for a 30-50 hp motor?
   a. 0
   b. 1
   c. 2
   d. 3
10. Power cable for use at voltages of 480 V and less should be rated at 600 V. Each conductor should be insulated with an ethylene propylene rubber (EPR) or equivalent compound rated for ___ °C conductor temperature.
   a. 90
   b. 95
   c. 100
   d. 110

ACRONYMS

ACI	American Concrete Institute
AFOSH	Air Force Occupational Safety and Health
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
API	American Petroleum Institute
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
BIL	Basic Impulse Level
BSR	Bureau of Standards Review
CFR	Code of Federal Regulations
CMMA	Crane Manufacturers Association of America
EIA	Electronic Industries Association
EJMA	Expansion Joint Manufacturers Association
ESF	Engineered Safety Features
H&V	heating and ventilating
HEI	Heat Exchanger Institute
HIS	Hydraulic Institute Standards
HMI	Hoist Manufacturers Institute
HVAC	heating, ventilating, and air conditioning
I&C	instrumentation and controls
IEC	Institute of Electrical Contractors

IEEE	Institute of Electrical and Electronics Engineers
IPCEA	Insulated Power Cable Engineers Association
ISA	Instrument Society of America
ITER	International Thermonuclear Experimental Reactor
JIC	Joint Industrial Council
MCC	motor control center
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NIOSH	National Institute of Occupational Safety and Health
NPH	Natural Phenomena Hazards, (DOE 5480.11)
NUREG	Nuclear Regulatory Commission document
OSHA	Occupational Safety and Health Administration
PIE	postulated initiating events
PPE	personal protective equipment
PVTC	pressure-volume-temperature-composition
RG	Regulatory Guide
RIA	Robotics Industrial Association
SAR	Safety Analysis Report, (DOE 5480.28)
SSC	Structures, subsystems, and components
TEMA	Tubular Exchanger Manufacturers Association
UHMWPE	Ultra high molecular weight polyethylene

ELECTRICAL POWER SYSTEMS

The electrical power system includes off-site sources and on-site AC/DC sources.

The switchyard is the interface between the grid and the facility receiving power from the off-site grid. Power is transformed from the grid voltage (usually 345 or 500 kV) to the voltages which will be used in the facility. Fusion device power supplies may be very large (500 MW) and of relatively high voltage (35-115 kV). The voltage supplied to the facility loads can be lower (13.8 kV) since the load will be significantly less. The switchyard will also contain the various high voltage breakers and disconnect switches.

Downstream from the switchyard, the electrical power distribution system is divided into two main parts, namely the fusion facility distribution system and the plant distribution system.

The fusion facility distribution system is primarily a high voltage system (35-115 kV) designed to supply the heavy (and often pulsed) loads for fusion facility operation. Included in this distribution system are the magnet power supplies and various plasma fueling and heating power supplies. Also included in this system will be the static volt-ampere-reactive (VAR) compensation and any energy storage equipment required.

The facility distribution system generally consists of four types (IV, III, II and I) of power to supply those loads which are required to operate independently of the Fusion Facility Distribution System. The four types of power supply are defined as follows:

Type IV (Non-Safety Class): Interruptible AC supply for those loads which can be interrupted indefinitely without resulting in plant damage or safety hazards to either on-site personnel or the public. Type IV power is supplied by the grid. This type of power supplies the normal facility operating loads.

Type III (Safety Class): Interruptible alternating current (AC) supply for those loads which can be interrupted briefly (5 minutes) without resulting in plant damage or safety hazards, but where longer interruptions may cause such problems. Type III is supplied from Type IV (grid) power when available, or by emergency (standby) generators. This type of power supplies loads which are needed to achieve and maintain the fusion facility in a safe condition. In the event of loss of grid power, the emergency generator power will fulfill the requirements.

Type II (Safety Class): Uninterruptible AC supply for those loads requiring a very secure continuous power supply. This class of power is obtained by the use of inverters (or motor generators) driven by Type I power.

Type I (Safety Class): Uninterruptible direct current (DC) supply for those loads requiring the most continuity of supply. This type of power is supplied by batteries, which are continuously recharged by Type III power through battery chargers fed from Type III MCCs. This class of power supplies safety and protective (DC) loads which must be available at all times.

General Safety Design Guidance

Electrical system functions should be designated safety functions if they are credited in the facility safety analysis in order to meet prescribed safety criteria. Systems or components needed to perform safety functions should be designated safety-class systems or components. Components which do not perform safety functions but whose failure causes the failure of a safety function should be designated safety-class components.

Fusion Facilities which require safety-class electrical systems should be supplied by two independent off-site sources and one on-site source of electric power to ensure the supply of electric power to each train of safety-class equipment

The electrical power system equipment that provides the power supply to safety-class systems and components to perform fusion facility safety functions are classified as safety-class. Other electrical systems should be non-safety-class (NSC). The safety-class electrical power system should be fed from the safety bus.

The safety-class electrical equipment defined by the facility safety analysis should be designed in accordance with the accepted design Standards given in this section. Where alternative methods are used, justification should be provided in the facility authorization basis.

Equipment that is used for both safety and non-safety functions should be classified as part of the safety systems. Isolation devices used to effect a safety system boundary should be classified as part of the safety system.

No credible failure on the non-safety side of an isolation device should prevent any portion of a safety system from meeting its minimum performance requirements during and following any design basis accident requiring that safety function. A failure in an isolation device should be evaluated in the same manner as a failure of other equipment in a safety system.

Potential System Safety Functions

The potential safety functions for the back-up electrical systems are:

1. Normal Operation and Maintenance - Normal and backup power should be on-line or available to supply safety functions. Specific potential safety functions are:

   a) Provide for ability to survive or recover from off-normal events.

   b) Monitor normal/back-up power

   c) Monitor status of active components which must function during Design Basis Accidents (DBA).

   d) Monitor equipment required to isolate in the event of on-site or off-site system faults.

2. Design Basis Accidents - The safety analysis should specify design basis accidents and related safety functions. The electrical power systems design provide power needed to enable the safety functions. The following are potential design basis accidents for back-up electrical power systems:

   a) Internal Initiators:

      1) Missile or pipe whip resulting from sudden failure of high energy systems. This accident has potential for causing release of radioactive material and simultaneously disrupting multiple electrical equipment.

2) Fire.

3) Human errors.

b) External Initiators:

1) Natural phenomena including earthquakes, hurricanes, tornadoes, floods, etc.

2) Aircraft and other missile impact.

3. Beyond Design Basis Accidents:

There are no system safety functions required for beyond design basis accidents.

Beyond design basis accidents include internal and external initiators whose frequency is lower than the design basis frequency limit specified in the safety analysis.

Safety-Class Design Criteria and Standards

General Design Safety Features

Electric power from the transmission grid to the on-site electrical distribution system should be supplied by two physically independent circuits designed and located so as to minimize, to the extent practical, the likelihood of their simultaneous failure under operating and postulated accident and environmental conditions.

If safe shutdown equipment is identified as a safety function, two completely independent sets of shutdown equipment should be provided. Each of the two sets of equipment should be capable of safely shutting down the fusion facility independently of the other set of equipment. Each set of equipment is referred to as a train of safety-class equipment, and is identified as Train “A” and Train “B.” Both trains “A” and “B” are completely redundant and independent of each other.

The on-site source of electrical power for each train is usually provided by safety-class diesel generator set, one for Train “A” and one for Train “B,” completely independent of each other with no inter-connections between the two. Alternate methods of comparable reliability are acceptable.

General Design Criteria/Standards

1. <u>Safety-class design criteria for protection against fire, natural phenomena</u>: Structures, systems, and components of safety-class electrical systems/components should be designed to be capable of withstanding the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods as established in fusion facility safety analysis, without loss of capability to perform their safety functions.

The design should minimize the possibility and the consequence of fire and its effects on the electrical safety-class equipment and devices.

The design should prescribe the use of fire resistant materials to the maximum practical extent possible for all equipment to be used for the safety-class functions. The design should provide for fire detection and suppression systems having appropriate capacity and capability to minimize adverse effects of fires on safety-class systems, structures and components. Rupture or inadvertent operation of fire suppression systems should not significantly impair the safety function of the electrical safety-class systems, equipment, structures and components.

The design should also provide for protection of safety-class equipment and systems from potential failure of non-safety-class hardware systems. Equipment, instruments and electrical systems, that provide for the isolation should be capable of withstanding the effects of design basis natural phenomena without failure of function and should be fail-safe in the event of power loss or failure within electrical systems.

The design bases for these structures, systems, and components should reflect: (1) Appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated, (2) appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena, and (3) the importance of safety functions to be performed.

2. Safety-class design criteria for environmental and dynamic effects: Structures, systems, and components of safety-class electrical systems/components should be designed to accommodate the effects of, and be compatible with, the environmental conditions associated with the normal operation, maintenance, testing, and postulated accidents (including loss of coolant accident, loss of flow accident, loss of vacuum accident, plasma transients, magnet transients, loss of cryogen, tritium plant events, and auxiliary system accidents).

Also, structures, systems, and components of safety-class should be designed appropriately to protect against dynamic effects, including the effects of missiles, pipe whipping, and environmental conditions associated with normal operation and the above postulated accidents.

3. Safety-class design criteria for sharing of structures, systems, and components: Structures, systems, and components of safety-class electrical systems/components of the fusion facility should not be shared among other facilities unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions.

4. Safety-class design criteria for inspection and testing of electric power systems: The design should provide for periodic testing of safety-class electrical items to prevent equipment failure. The tests and inspections should assess the parameters related to their safety functions. The testability of safety-class on-site AC and DC power systems should be designed to meet the following guidelines or equivalent.

AC systems and components: IEEE 308 and 338 Standards.

DC systems and components: IEEE 308 and 387 Standards.

5. Design criteria for electrical penetration assemblies (Safety-Class and Non-Safety Class) of Fusion Facility containment: Containment electrical penetrations should be designed to be capable of withstanding, without loss of mechanical integrity, the maximum possible fault current versus time condition that could occur given a single random failure of circuit overload protective devices located in circuits of the on-site safety-class AC/DC power systems. IEEE 317 Standard., Electrical

Penetration Assemblies in Containment Structures for Nuclear Stations (see also Regulatory Guide 1.63), should be used as a design guide.

Penetrations should be designed to meet the same requirements of robustness and leak tightness as the penetrated containment or confinement (shield) system. The safety analysis should determine the safety-class of each electrical confinement penetration.

6. Safety-class design criteria for electric power systems: Safety-class power supplies, including batteries, emergency power supply from diesel generator(s), and the on-site electric distribution system, should have sufficient independence, redundancy, and testability to perform their safety functions assuming a single failure.

Acceptance is based on meeting, either wholly or in part as necessary, the following specific safety design criteria:

IEEE 308 Std., Criteria for Class 1E Power Systems for Nuclear Power Generating Stations (see also Regulatory Guide 1.6)

IEEE 323 Std., Qualifying Class 1E Equipment for Nuclear Power Generating Stations

IEEE 336 Std., Standard Installation, Inspection and Testing Requirements for Power, Instrumentation, and Control Equipment at Nuclear

IEEE 338 Std., Standard Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems (see also Regulatory Guide 1.118)

IEEE 344 Std., Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating

IEEE 352 Std., Guide for General Principles of Reliability Analysis of Nuclear Power Generating Station Safety Systems

IEEE 379 Std., Standard Application of the Single-Failure Criterion to Nuclear Power Generating Safety Systems (see also Regulatory Guide 1.53)

IEEE 382 Std., Standard for Qualification of Actuators for Power-Operated Valve Assemblies with Safety-Related Functions for Nuclear Power (see also Regulatory Guide 1.73)

IEEE 383 Std., Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations

IEEE 384 Std., Standard Criteria for Independence of Class 1E Equipment and Circuits (see also Regulatory Guide 1.75)

IEEE 387 Std., Standard Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations (see also Regulatory Guide 1.9)

IEEE 450 Std., Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary (see also Regulatory Guide 1.129)

IEEE 577 Std., Standard Requirements for Reliability Analysis in the Design and Operation of Safety Systems for Nuclear Power Generating Stations

IEEE 603 Std., Standard Criteria for Safety Systems for Nuclear Power Generating Stations

Radiation/Contamination and Equipment Life

Provisions should be made to avoid installation of safety-class electrical equipment, systems, and components in areas of high radiation/contamination levels to prelude exposure that could degrade the elements quality.

The electrical emergency/back-up power system, equipment and components should be qualified for the life time radiation environment. The equipment structural design and qualification analysis should use conservative end of life parameters. If a component expected lifetime is less than the facility design life, the design should provide for component replacements.

Control and Instrumentation

The emergency/back-up power systems should be provided with instrumentation and control elements and components to monitor the necessary parameters to perform their safety functions for normal operation and for cases of emergency (Design Basis Accidents). The safety analysis should identify and the design should implement:

1. Instrumentation to monitor the safety-class parameters.

2. Controls to maintain the measured parameters within the operational limits.

The design of safety-class systems should include sufficient redundancy and diversity to ensure that single failure will not result in total loss of instrumentation or controls for required safety function.

Design Considerations

General

The preferred supply voltages are 13,800V, 3-phase, 60-Hz for all motors rated 3000-hp and above; 4,160V, 3-phase, 60-Hz, for all motors rated 251 to 2500-hp; and 480V, 3-phase, 60-Hz for all motors 1 to 250-hp. Motors rated 3/4-hp and less may operate at 120V, single phase, 60-Hz, except critical equipment and motor-operated valves (MOVs) that will be operated at a supply voltage of 480V, 3-phase, 60-Hz.

Electrical equipment and systems essential to safety functions defined in the safety analysis should be identified as Safety Class, should conform to IEEE standards and guides for Class 1E electrical systems and components.

Safety-class Diesel Generators and/or Combustion Turbine Generators

One non-safety-class and two safety-class diesel generators or combustion turbine-generators should be provided for the fusion facility.

The safety-class diesel generators (or combustion turbine generators) should be designed in accordance with the requirements of USNRC Regulatory Guide 1.9 and should meet the requirements of IEEE-387 Standard. The capacity of diesel generators (or combustion turbine generators) should be sufficient to accommodate all safety-class loads as defined in fusion facility safety analysis.

There should be no direct interconnections between the emergency/back-up electrical power sources of the facility. There should be no provisions for automatically paralleling these power sources within the facility, and administrative control should be provided to prevent manual paralleling of these power sources. Provisions should be made for auto/manual synchronizing each emergency/back-up power source, to its respective bus for periodic testing during normal facility operation.

Each emergency/back-up power source and its auxiliaries should be located in seismically qualified separate rooms.

After start initiation, the power source, diesel or combustion turbine generator, should accelerate to and stabilize at synchronous speed with rated frequency/voltage within the time period specified in the safety analysis, and accept the first block of loads.

The safety-class diesel generators should be manufactured and tested in accordance with ANSI Standards C50.10 and C50.12, NEMA Standard Publication MG-1, and IEEE Standards 115 and 386.

If an alternative type of power source is chosen, e.g. a dam and hydroelectric turbine, it should be manufactured and tested according to the requirements of procurement specifications.

Switchgear and Load Centers

The switchgear should be fully rated for the maximum expected short-circuit current and continuous current capacity. All switchgear breakers should be drawout type, electrically operated, stored energy air circuit breakers.

The electrical equipment with 480 V or higher for the safety-class systems should be designed and qualified in accordance with IEEE Standards 344 and 323 for Class 1E electrical equipment.

Fault calculations should be made in accordance with the latest issue of ANSI Standards C37.010 and C37.13.

Selected high voltage switchgear breakers including 480V should be provided with local control in addition to the remote control in the control room and the automatic controls. The control voltage should be 125 VDC.

All switchgear and load centers should be located indoors. Access space should be provided in back and in front of the switchgear and load centers as recommended by the manufacturer.

Large 480V loads (60 through 250-hp motor loads, 100 through 400-kW non-motor loads) and motor control centers should be supplied from 480V load centers. Each load center should be provided with 4160 to 480V, 3-phase, 60 Hz, dry type transformer, with a 60 kV Basic Impulse Level (BIL) primary rating. “De-energized change” taps should be provided the same as specified for the facility auxiliary transformers. The 480V secondary winding of the transformer should be wye-connected with the neutral solidly grounded, except where the loads are the pressurizer heaters, in which case the secondary should be delta connected. The transformer primary should be fed from the 4160 V switchgear by cable. The transformers and the switchgear buses should have sufficient capacity and should be connected so that overloading under any condition of operation is prevented. A separate ground fault relay should be provided for the transformer neutral and each load center feeder.

Motor Control Centers

AC Motor Control Centers:

The 480 V MCCs should be metal enclosed, NEMA Class II, Type B. All 480 VAC motor control center motor starter circuits should be full-voltage non-reversing and full-voltage reversing, combination type with breakers, contactors, and individual control transformers. Transformers supplying the control power should be of uniform rating for similar units and will be sized to provide for the addition of relays and other loads. The minimum size should be 150 V-amperes. Starter sizes should be based on motor hp, voltage, and type of service. Table II-3 below covers low-voltage (600 V and below) NEMA Class A (for induction motors) general purpose starters.

Table II-3. Load voltages for general-purpose starters

Size of Starter (480 volts, 3-phase)	Type of Load
0	Heater
1	0 - 10 hp motor
2	15 - 25 hp motor
3	30 - 50 hp motor

All MCCs should be designed to contain approximately 20% spare circuit breakers, motor starters, and/or spaces. Essential circuits should be designed to provide for the maximum possible continuity of unit operation so that after a brief loss of power or voltage dip, the starter will return to its original position after the power is restored.

DC Motor Control Centers:

The DC MCCs will be similar to the 480 VAC MCCs except that starters will be reduced-voltage type to limit the motor starting inrush current to 200% of rated current. Some loads will be controlled locally at the equipment in addition to automatic remote control from the control room.

Direct Current Systems

The facility direct current power for safety-class systems should be provided by several independent DC systems as required for normal and abnormal plant operations. Each safety-class DC system will consist of one independent 125 VDC battery, battery charger, and a DC control center. DC motor control centers will be provided where required for motor-operated valves and pump motors as indicated above.

Each DC subsystem will be of adequate size to provide control and switching power to safety-class systems and components. The DC power systems should be designed so that no single failure will result in conditions that prevent safe shutdown of the fusion facility. Redundant safety-class loads will be distributed between the redundant DC subsystems.

The DC systems will operate ungrounded. A DC ground detector relay for each system will be provided to annunciate an undervoltage condition.

All batteries will have sufficient capacity to supply power to the DC systems for the time period specified in the safety analysis without the support of the charger.

The capacity of each battery charger will be based on the largest combined demands of the various steady-state loads and the charging capacity required to restore the battery from the design minimum charge state to the fully charged state within 12 hours under any facility operating condition.

Calculations for battery sizing will be in accordance with the method presented in IEEE-485. The Class 1E system design should be in conformance with IEEE 308.

Vital Instrumentation and Control Power Supply

Independent ungrounded vital instrumentation and control power supplies should be provided to supply emergency/back-up power to instruments and controls systems credited in the safety analysis report. Each vital AC power supply will consist of an inverter, distribution panel, and manual transfer switch. Normally, the distribution panel will be supplied by the inverter. Each inverter will be supplied by a 480 VAC safety-class power source and a separate safety-class 125 VDC subsystem. A backup supply will be provided to each vital AC bus from a safety-class AC regulating type transformer through a manual transfer switch. The capacity of each regulating transformer should be adequate to meet the largest demand of any of the two vital AC distribution panels to which each regulating transformer may be connected.

Motors

All motors for safety-class equipment should be rated, manufactured, and tested in accordance with NEMA Standard MG-1 and other applicable USA and ISC standards.

All motors should be sized to ensure operation within the temperature limits given in NEMA Standard MG-1. All DC motors should be rated at 120 and 240 volts. The voltage rating of the AC motors, in general, should be as in Table II-4 following:

Table II-4. Voltage ratings for AC motors

1.	All motors for motor-operated valves and Class 1E damper motors	480 volts, three-phase, 60 Hz
2.	Motors 1/3 hp and below, except as specified in item 1 (above)	115 volts, single-phase, 60 Hz
3.	Motors from 1/2 hp through 250 hp	480 volts, three-phase, 60 Hz
4.	Motors from 251 hp through 2500 hp	4,160 volts, three-phase, 60 Hz
5.	Motors 3000 hp and above	13,800 volts, three phase, 60 Hz

All AC motors should be suitable for across-the-line starting. Non-safety-class motors should be designed to accelerate the connected load with a minimum of 80% rated voltage at the motor terminals. Safety-class motors should be designed to accelerate the connected load with a minimum of 75% rated voltage. Wherever possible, DC motor starting current should be limited to 200% of rated current. The full-voltage starting current of AC induction motors rated 250 hp or more should not exceed 6.5 times the full-load current.

In general, motors 60 hp through 250 hp will be fed from load centers. Motors 50 hp and below, and MOVs, will be fed from MCCs.

All safety-class motors should have non-hygroscopic Class F or Class H insulation with Class B temperature rise. All non-safety-class motors should have at least Class B insulation sealed against moisture and contaminants.

Enclosed motor windings should have moisture resistant Class B insulation systems, suitable for power plant service, conforming to the requirements of NEMA Standard MG-1.

Class F or H insulation may be used if the temperature rise does not exceed limits for Class B insulation.

All motors 3 hp and above located outdoors, and motors 25 hp or larger located indoors, should have space heaters. Open, drip-proof motors 3 hp and larger in damp, indoor locations should have space heaters. Wherever possible, space heaters should be rated for 220-240 volts, but are to be connected to a 120 volt single-phase service.

All motors installed indoors should be open, drip-proof, and fully guarded or should be totally enclosed, and fan cooled. Motors installed outdoors should be NEMA weather protected Type I or should be totally enclosed and fan cooled.

Stator resistance temperature detectors (RTDs) should be provided for all medium voltage motors. Rotor temperature monitoring should be provided on all motors above 1000 hp.

Power, Control, and Instrumentation Cables

Except in the case of thermocouple and lighting cables, all conductors should be Class B stranded, tin-coated or lead-alloy-coated, soft or annealed copper. The following classes of cables should be provided:

15 kV and 5 kV power cable

600 volt power cable

Lighting wire rated 600 volts

Control cable rated 600 volts

Instrument cables and special cables

Communication cables

All cables should be capable of passing the cable tray vertical flame test set forth in IEEE-383. Individual conductor in cables should be capable of passing the vertical flame test of subsection 6.19.6 of IPCEA S-19-81 and/or S-66-524.

Safety-class cables which must survive exposure to abnormal environmental conditions such as those following postulated design basis accidents should be qualified for such service per IEEE-383.

The medium-voltage power cables for the 13.8 kV system should be rated at 15 kV, and the cables for the 4.16 kV system should be rated at 5 kV. The conductors should be insulated with an ethylene propylene rubber (EPR) or equivalent compound rated for 90^{o} C conductor temperature. The 13.8 kV cables should be single-conductor (1/C) shielded with hypalon or equivalent jacket. The 4160 V cables in trays should be either 1/C or 3/C cables with a hypalon or equivalent jacket. The 4160 V cables in conduit and in underground ducts should be 1/C, shielded cables with a hypalon or equivalent jacket.

Power cable for use at voltages of 480 V and less should be rated at 600 V. Each conductor should be insulated with an ethylene propylene rubber (EPR) or equivalent compound rated for 90^{o} C conductor temperature. Multiple conductor cables should be used for all wire sizes up through No. 2 American Wire Gage (AWG) and should be provided with an overall jacket of neoprene, hypalon, or equivalent material. Single conductor cables should only be used for sizes No. 1/O AWG and larger, except in special cases where a calculation is made to verify the acceptability of and need for single conductor power cables No. 2 AWG or smaller. Insulation and jacket thicknesses should be in accordance with Insulated Power Cable Engineers Association (IPCEA) standards.

Control cables should be rated at 600 V. Each conductor should be insulated with cross-linked polyethylene, Tefzel, ethylene propylene rubber, or equivalent compound rated for 90^{o} C conductor temperature. Multiple conductor cables should be used for all control circuits; they should be provided with an overall jacket of neoprene, hypalon, or an equivalent material. Insulation and jacket thicknesses should be in accordance with IPCEA standards. Conductor size for control cables should be at least No. 16 AWG. Control cables between switchyard and plant area should be of the shielded type.

Instrumentation cables should be multi-conductor, No. 16 AWG, twisted and shielded, and should have 600 V insulation. Shield grounding should be in accordance with the equipment manufacturer's recommendation. Multi-paired cables should be used wherever possible between terminal boxes and the cabinets. The insulation and jacket material should be the same as specified for the control cable. All thermocouple circuits should be No. 18 AWG or 20 AWG with twisted and shielded leads. Multi-paired cables should be used wherever practicable.

Coaxial and triaxial cables should conform to the specifications of the suppliers of the systems in which they are used.

All individual load circuit conducts should be capable of carrying 125% of rated full load at ambient temperature with due allowance for cable grouping. Transformer primary and secondary feeder cables should be capable of continuously carrying 115% of the maximum transformer rating. Cable size should meet the requirements of short circuit duty, and limit the voltage drop to 5% (2% in supply feeder cable plus 3% in branch circuit feeder equals 5% overall voltage drop).

Cable current carrying capacity (ampacity) information contained in IPCEA Publications P-46-426 and P-54-440 should be used to select cable size. For circuits which will be routed partly through conduit and partly through trays or underground ducts, the cable size should be based on the ampacity in the portion of the circuit with the highest conductor temperature.

The conductor size should be large enough to ensure that the conductor temperature, after a short circuit, (assuming rated conductor temperature prior to the short circuit) will not exceed 250^0 C.

For purpose of sizing the cable, it should be assumed that over load operation at the emergency temperature of the conductor will be limited to 100 hours per year, and that such 100-hour overload periods will not occur more than five times during the life of the facility. The emergency temperature rating is 130^o C for cross linked polyethylene and EPR insulated cable.

Raceways and Trays

Underground, exposed, and embedded conduits should be used through the facility where the use of trays is not economical or practicable.

Underground conduits for other than safety-class circuits should be type PVC ducts encased in a concrete duct bank. Underground safety-class circuits should be run in cable trenches, tunnels, or duct banks designed to withstand the SSE. The minimum size of conduit used in duct bank should be 2 inches.

The top of duct banks should be buried a minimum of 2 feet below grade. Underground conduit within duct bank for non-Category I (non-seismic) installation should be non-metallic type DB. The duct encasement should be reinforced concrete. The surrounding encasement should be a minimum of 3 inches thick. PVC type DB encased in reinforced concrete should be used for a Seismic Category I duct bank. Rigid steel conduit encased in reinforced concrete should be used for isolated runs. Single conduit leaving a duct bank between manholes or groups of conduits should be rigid steel galvanized encased in un-reinforced concrete with 3 inch cover all around. The top surface of the electrical duct banks should be covered with red dye on the surface to distinguish them from other underground structures.

All safety-class circuits inside the facility should be run in trays or in rigid steel conduit for all sizes.

Safety-class circuits should be routed only through safety-class raceways. All non-safety-class circuits originating in safety-class equipment (associated circuits) including space heater circuits should be routed in the same manner as safety-class circuits up to the isolation device. No other circuits should be routed through safety-class raceways.

Trough-type cable trays should be utilized where practicable. Tray strength should be verified by tests in accordance with the latest revisions of NEMA VE 1-1991 Metal Cable Tray Systems. The fill of power trays should be limited to 30% of usable area of 3 inch deep tray. The fill of control trays and instrumentation trays should be limited to 30% area. The loading of each section of tray should be calculated based upon the cable manufacturer's data.

Separate power trays and control trays should be provided in the vicinity of motor control centers and 480 V switchgear. In outlying areas, control cable and 600 V power cables may be run in the same tray. Lighting branch circuits should not be run in trays in any location, except for lighting panel feeders which will be 90^{o} C cable.

Trays for cables of different voltage levels should be stacked in descending order with the higher voltage. Instrumentation trays should always be at the bottom. At least 12 inches of clear space should be provided between tray levels.

Trays should be made of hot-dipped galvanized steel. Adequate tray support must be provided to bear the electromagnetic loading in cables and trays when trays are used in areas of strong magnetic field gradients and time varying fields.

Instrumentation cables should not share the same raceway with power cables, control cables, or telephone cables.

Cable tray systems related to safety-class electrical systems should be designed the requirements of IEEE-344.

Separate conduit should be supplied for the DC battery feeders.

Cable trays should be designed for a dead cable load of fifty pounds per foot, plus a single live load of 200 pounds applied at any point along the tray between supports. In addition, tray supports should be designed for loads due to the interaction between DC currents and the local magnetic field. In general, the medium voltage cable trays will be sized to allow spacing between cables of more than one cable diameter in a single layer. Fire stops of fire retardant materials will be used at floor and wall penetrations and long vertical runs. Normally, trays will not be routed over areas of high fire hazard; e. g., main lubricating oil reservoir, diesel generator sets, etc.

Cable tray systems related to safety-class electrical systems should be designed to the requirements of IEEE-344.

Electrical Penetrations

Electrical penetration assemblies should be provided as a means of passing electrical circuits through the containment building wall while maintaining the integrity of the containment pressure barrier. The assemblies should meet the requirements set forth in IEEE-317. The assemblies should be inserted in and bolted to feed-through sleeves welded to the steel liner of the wall of the containment building and have a double electrical conductor seal. A seal should be provided at the bolted connection to the feed-through sleeve.

At least four separate electrical penetration areas should be provided to maintain the physical separation specified in USNRC Regulatory Guide 1.75. Where Safety-class redundant protection system sensors are located within the containment building, each circuit should be brought to a penetration area with separation maintained among the redundant circuits.

The electrical penetration assemblies should conform to USNRC Regulator Guide 1.63.

Three basic types of electrical penetrations should be provided:

Type I Medium voltage power, 15 kV or 5.0 kV

Type II Power and control, 600 volts and below

Type III Instrumentation, thermocouple, coaxial, triaxial, and other special circuits

Circuit loading should be limited, based upon the manufacturer's recommendations, to ensure that the temperature will not cause excessive drying of the concrete adjacent to the penetration assemblies.

Provisions should be made for periodic leak testing of the electrical penetration assemblies.

Separation of Facility Safety Systems/Components

Physical separation and independence of electrical systems should be established in accordance with IEEE-384, Standard Criteria for Independence of Class 1E Equipment and Circuits, and USNRC Regulatory Guide 1.75 to ensure meeting the requirements of IEEE-308 and 603.

Separation requirements should be applied to the following electrical systems when these systems serve safety functions:

Cable tray and conduit system

Circuit wiring

Diesel generator or alternate emergency/back-up power system

Medium and low voltage switchgear

Motor control centers

DC batteries, chargers, and distribution system

Electrical penetrations

Physical separation and independence should be provided for the four fusion device protection system channels, identified as Channels 1, 2, 3, and 4, and for two load groups of safety related equipment, identified as Trains A and B.

Redundant Channel Separation:

Raceways for the four redundant protection channels, engineered safety feature (ESF) actuation signals, and the two safety related trains should be physically separated from each other. However, Channel 1 and an ESF actuation signal channel may be run in the same raceway stack without separation as Train A; also Channel 2 and an ESF actuation signal channel may be run in the same raceway stack as Train B without separation. Channels 3 and 4 should conform to the separation requirements as required. Separation should be maintained or a barrier should be used to the terminating devices.

Non-redundant Separation:

Circuits for non-redundant balance of plant (BOP) functions originating at safety-class equipment should be provided with isolation devices or may be run in raceways used by associated safety-class circuits; however, the routing of such non-redundant circuits will be controlled the same as the safety-class circuits.

Cable Tray Separation:

In general, physical separation of cable trays for redundant safety-class circuits should be maintained by a minimum of three feet horizontal separation. Vertical stacking of redundant cable trays should be avoided, if at all possible, but where such arrangement is employed, minimum vertical spacing should be five feet between the two groups. Where this is not practicable, barriers will be provided or rigid steel conduit and thermal barriers should be used. Divided cable trays should not be used to separate redundant systems.

The cable tray system should be designed and installed according to the requirements of IEEE-384. (see also Regulatory Guide 1.75).

Cable Color Coding

Cables for redundant systems should be color coded. Cable trays and conduits carrying these cables should be identified by the same color marking or colored labels at intervals, when passing through a barrier, or wherever confusion may exist. Acceptable color coding of the cables is as follows:

Safety Class:

Train A Red

Train B Green

Channel 1 Red

Channel 2 Green

Channel 3 Yellow

Channel 4 Blue

Non-safety class: Black

Reliability Design Features

To meet the expected stringent reliability requirements and to keep partial power system failures from having a cascading failure effect, the system should be designed with the following features.

1. The design assumes that three sets of lines (circuits) should connect the facility to the switchyard (grid); two for fusion facility operation and one for main (power) generator output. To maximize the separation of pulsed (tokamak) and plant loads, it is assumed that one set of circuits will supply the tokamak loads while the second will supply the plant loads during fusion facility operation. In the event of loss of one circuit, the fusion facility load would be shed (plasma shutdown) and the remaining set of circuits would supply the plant loads. During the fusion power generation (if designed), the third set of circuits will be used.

2. Since each safety bus has double supply paths, any single failure can be limited to a single bus. This provides redundant backup capability with a high degree of independence.

3. Each type of power is subdivided into two, three, or four segments with limited cross ties to provide redundancy without excessive cross-links.

4. The distribution system should have automatic fast transfer logic systems which sense the loss of supply to a bus, determine what alternative supplies are available, and carry out switching to connect the affected bus to a viable power supply.

5. Physical separation of redundant buses will be provided for protection against common causes of failure (e.g. fires, or in-plant flooding).

6. Four 125 VDC buses are proposed to provide four independent channels of safety-class system instrumentation to permit the use of single failure resistant, 2 out of 3, 2 out of 4, or 3 out of 4 channel voting logic on Fusion Facility Protection Systems.

7. The use of two emergency (standby) generators for Safety Train A and B is proposed, each with the sufficient capability of providing power for the emergency loads needed to safely shut down the fusion facility.

8. Suitable test capability will be required to allow periodic testing of all safety-class systems and automatic transfer systems as well as periodic operation of all circuit breakers and disconnects without adversely affecting system operation or compromising safety. Depending on the reliability requirements, such testing may have to be on-line.

Independent Design Review

The primary objective in the independent design review of the Emergency/Back-up power system is to determine that these systems satisfy the acceptance criteria and will perform their design functions during fusion facility normal operation, anticipated operational occurrences, and accident conditions. In the independent design review, the descriptive information, including the design bases and their relation to the acceptance criteria, preliminary analyses, electrical single line diagrams, functional logic diagrams, preliminary functional piping and instrumentation diagrams (P&ID), and preliminary physical arrangement drawings are scrutinized to determine that there is reasonable assurance that the final design will meet the these objectives.

Electrical Power Systems

Combustion turbine-generators

Recently, the combustion turbine-generator has been used as an emergency power source in the power plants and the other heavy industries due to it's high reliability, availability, and maintainability. Therefore, design should perform an application study for the use of combustion turbine as an emergency power source in the fusion facility. (see ASME 91 and West 211)

Grounding

A facility grounding grid consisting of bare copper cables buried beneath grade will be furnished to limit step and touch potentials to safe values under all fault conditions. Bare copper risers should be furnished for all electrical underground ducts and equipment, and for connections to the grounding systems within buildings. The design analysis will be based on the procedures and recommendations of IEEE-80.

Grounding within buildings should be in accordance with the NFPA 70. Grounding systems connected to the station ground grid should be provided in each building with connections made to metallic tanks, equipment, cable trays, and exposed metal structures. Every other perimeter steel column should be connected directly to the ground grid. Each major piece of equipment or tanks should have two ground connections diagonally to each other.

System and Equipment Grounding

System and equipment grounding should be in accordance with IEEE-142.

One No. 4/0 AWG bare copper cable should be installed with each underground electrical duct run. It should be connected with the ground cables from other duct runs at each manhole. All hardware in each manhole should be bonded to these ground cables.

All metallic structures, towers, poles, and like items should be connected to the ground grid.

All switchgear, motor control centers, and control cabinets should be furnished with horizontal ground bus. The ground bus in switchgear and MCC's should be connected to the grounding system with one No. 4/0 AWG copper ground cable at each end tied to the building steel or a ground pad set in the floor. The ground bus in control cabinets should be connected to the grounding system with No. 2/0 AWG Stranded copper cable at each end tied to the building steel or a ground pad set in the floor. An insulated grounding grid should be installed in the control room and computer room for grounding the computer and any other panel that needs grounding connected to the facility grounding system.

Cathodic Protection

A recommendation for cathodic protection should be made based on the results of soils analysis and resistivity readings.

Consideration should be given for protection of such facility structures as underground pipes and storage tanks, surface mounted storage tank bottoms, sheet piling, and concrete encased steel for the fusion facility containment or confinement building.

Lightning Protection

A lightning protection system should be provided for all major structures. Design and installation of the system should be in accordance with the NFPA-780.

Lightning protection should be provided for all buildings that need to be protected. The system should be connected to the station ground grid and to supplementary ground rods if required.

Station type lightning arresters will be provided on each phase of the incoming transmission lines to the main step-up and the start-up transformers. The arresters will be either mounted on each transformer, or separately supported and located near each transformer with connections to the high voltage bushings. The voltage rating of the lightning arresters should be compatible with the ratings of other surge protective equipment connected to the system.

Fire Detection and Fire Protection

The fire protection system should be designed in accordance with the requirements of National Fire Protection Association and the applicable local codes and regulations. Equipment and facilities for fire protection will be provided to protect facility equipment, structures and personnel from fire and the resultant release of toxic vapors. If there is a possibility of an explosion, the designer should consider the use of an explosion suppression system (NPFA 69).

Smoke, ionization, and fire detectors should be provided in enclosed areas where electrical switchgear, motor control centers, control cabinets, etc., are located. Detectors should also be provided in areas of heavy concentration of cable trays, in ventilation ducts, penetration rooms, the diesel generator rooms, and selected areas of the containment or confinement. Smoke and fire detection alarms will be annunciated in the control room and at the fire department or fire brigade.

Fire-walls, barriers and physical separation of redundant safety features electrical equipment should be provided as required. Vertical cable tray runs will have horizontal fire barriers where required. Where cable trays pass through openings in walls or floors, fire stops should be provided.

Any smoke from fires should be controlled so that heat and toxic combustion products are kept from the control room and computer control areas. Smoke movement and control should be accomplished with ventilation dampers activated by smoke detectors in ducts. Designers should consider using smoke hatches in building roofs. NFPA 92A and NFPA 204M give smoke control design guidance.

REMOTE MAINTENANCE SYSTEMS

The remote handling systems include robotic, telerobotic, teleoperated, and crane systems for servicing the areas of a fusion facility with either high potential personnel hazards or where other methods are not practical. The latter includes combinations of high accuracy, large capacity, and limited space unique to the fusion facility that will have to be addressed.

Remote handling systems should be provided to minimize personnel exposure to radiation and other hazards during the operation and maintenance. Remote handling systems should be considered where it is anticipated that personnel exposures would otherwise approach dose guideline limits or where contaminated puncture wounds could occur.

The following sections give generalized requirements for remote handling systems derived from the unique characteristics of the fusion facility. These should be viewed as additions to the requirements of more traditional robotic systems.

System Definitions

Robot - An automatic, position-controlled, reprogammable, multi-functional manipulator having several axis, capable of handling materials, parts, tools, or specialized devices through variable programmed operations for the performance of a variety of tasks.

Telerobot - A robot that is directed through a series of preprogrammed functions or steps by an operator, in menu driven, teach and play, or simulator functional steps.

Teleoperator - A robot that is under the immediate control of an operator, to perform a series of robotic motions or functions within workcell constraints, including collision avoidance and automatic alignment.

Crane systems - A conventional crane of specialized nature or “smart” crane, such as a “swing free” crane.

General Safety Design Guidance

Remote handling systems should be provided to minimize personnel radiation exposure during the operation and maintenance of the fusion device. ALARA concepts should be applied to minimize exposures where cost effective. Remote handling systems should be considered where it is anticipated that personnel exposures would otherwise approach dose guideline limits or where contaminated puncture wounds could occur.

Systems or components needed to perform safety functions should be designated as safety-class systems or components. Components which do not perform safety functions but whose single failure causes the failure of a safety function should be designated safety-significant components.

Potential System Safety Functions

Normal Operations

Safety-significant remote handling systems and components should not cause a Safety System to fail under normal plant operating conditions. Potential safety functions during normal operation include:

1. Erect portable radiation shielding panels
2. Place or relocate experimental devices in high radiation fields
3. Test or inspect SSCs as necessary to assure performance of safety functions

Maintenance

Remote handling systems and components should not cause a collision with safety systems or components while performing normal or abnormal plant maintenance. System design and operational controls should limit operator radiation exposure. Potential safety functions during maintenance include:

1. Erect portable radiation shielding panels
2. Replace equipment or components in high radiation fields or transport equipment or components to a hot-cell.
3. Decontaminate SSCs in preparation for maintenance

Design Basis Accidents

Remote handling equipment classified as safety-class should be designed to function both during and after a design basis event. Safety-significant remote handling systems and components should not drop their loads, collide with structures or releasing gas or aerosols under basis accident conditions. Safety-significant remote handling systems and components should also not cause safety systems or components to fail under design basis accident conditions. Potential safety functions during design basis accidents include:

1. Install/place diagnostic instruments
2. Install consequence mitigation devices in high radiation fields or otherwise unsafe conditions.

Beyond Design Basis Accidents

There are no system safety functions required for beyond design basis accidents. Beyond design basis accidents include internal and external initiators whose frequency is lower than the design basis frequency specified in the safety analysis.

Structural

General

Remote handling systems and components encompass all components up to the primary plant support structures. The design allowables for safety-class or safety-significant remote handling systems and components should be in accordance with codes identified in Table 2 of this volume.

Normal Loads

Remote handling systems should withstand the static, dynamic, thermal, and normal plant loads, without exceeding applicable code allowable stresses.

Natural Phenomena and Accident Loads

Safety-class remote handling systems should be designed to withstand effects of natural phenomena and design basis accidents. Loads from natural phenomena and accidents should not cause safety-significant remote handling systems and components to fail in such a manner as to cause failure of safety-class components or systems.

Materials

Materials of construction should be qualified for the life time service with the anticipated thermal and radiation environment. The structural design analyses should use conservative end of life properties. If a component's expected life time is less than the fusion facility life time, design should provide for component replacement. Additionally, the minimization of material activation and the ability to decontaminate materials should be considered. The nature of a fusion facility is such that very high levels of radiation, temperature, magnetic flux, and neutron flux are expected. Additionally, the presence of hydrogen, deuterium, and tritium gases is anticipated during off normal events.

The effects of galvanic or chemical corrosion should be evaluated as part of the material selection process.

Materials used in the fabrication of remote handling equipment load bearing members should conform to standards defining chemical and mechanical properties specified by the designer. Allowable stresses in remote handling equipment structural steel members during normal operation should not exceed those codes identified in Table 2, and allowable design stresses in mechanical components should provide a factor of safety of 5 when under rated load. Brittle fracture and fatigue during all operation and testing conditions should be design considerations.

Joint and weld details should be designed to prevent fracture, lamellar tearing, low-cycle fatigue and embrittlement.

Lubricants, sealants and protective coatings should be compatible with their intended service and environment.

In the selection of materials, including lubricants, sealants and electrical insulation for equipment to be stored or used in the primary confinement, design life radiation exposure (during normal operation and, where applicable, accident conditions) should be considered and materials selected so there will be no loss in function for the design life of the equipment.

The surface finish of all external materials should allow for ease of radiological decontamination. Highly polished, non oxidizing, and non painted surfaces should be used so as to not entrap radiological material or produce mobile dust.

The potential for hydrogen embrittlement and weakening of structural members should be considered in all locations where exposure to hydrogen, deuterium, or tritium is anticipated.

The radiological activation of materials in areas of high gamma and neutron fluxes should be considered in the choice of materials. This includes metals, greases, fluids, and elastomers.

Instrumentation and Controls

The following instrumentation and control features should be provided in the design of the remote handling equipment as necessary to prevent damage to the handling equipment, to nearby safety-class or safety-related SSCs, and to the handled components; to provide for personnel safety; and to remotely recover equipment (to prevent the necessity of personnel recovery of equipment):

1. Underload - An interlock actuated upon a reduction in load, while lowering with grapple attached, at other than full down position, to prevent any further downward travel.

2. Overload - An interlock actuated upon an unacceptable increase in hoisting force to prevent upward travel.

3. Up-Position - An interlock set at a predetermined operational limit to prevent any further upward travel.

4. Down-Position - An interlock set at the predetermined operational limit to prevent any further down travel.

5. End-Travel (hardstop) - Physical limit to translation.

6. Up-Limit (hardstop) - Physical limit to hoisting.

7. Slow Zone - Region of travel where a reduction in hoist speed is mandatory and automatic.

8. Non-Simultaneous Motion - Automatic restriction against simultaneous hoisting and translating motions.

9. Grapple Release - An interlock to prevent opening a grapple under load.

10. Bridge Travel - An interlock at a predetermined operational bridge travel limit.

11. Trolley Travel - An interlock at a predetermined operational trolley travel limit.

12. Slack Cable - An interlock actuated at a loss of cable load to prevent further downward travel.

13. Translation Inhibit - An interlock to prevent bridge or trolley movement unless its associated hoist is at or above a predetermined operational up position

14. Robotic systems should be provided with intelligent systems to avoid known structures and obstacles. This may include direct sensing of obstacles or knowledge based systems that have been preloaded with the location of obstacles.

15. Remotely controlled systems should be provide with a backup means of safe release of attached radiological hazardous materials, to facilitate remote recovery of failed remote handling equipment for repair.

16. Redundancy of critical controls should be provided to prevent single mode control failure of remote or robotic equipment causing unplanned or unanticipated equipment motion.

17. Provision should be made for maintenance of anticipated large capacity remote or robotic equipment in the presence of personnel, without creating impact hazard to the personnel. It is anticipated the most equipment will require a minimum of maintenance functions while energized, typical of robotic systems. This must be provided for in a personnel safe manner.

18. The expected high presence of radio frequency and magnetic fields during both normal and off normal operation should not create hazards to personnel through unplanned movements or other means.

Manual bypasses for interlocks may be supplied at the discretion of the designer.

Electrical

The remote maintenance systems should be designed to the equivalent of the National Fire Protection Association Class 1, Division 1 requirements. It is assumed, but not required, that this would be met with the pressurized, interlocked systems approach.

Function Protection for Natural Phenomena

Safety functions should be assured for loads from natural phenomena. Design should provide for protection of safety-class equipment and systems from potential failure of non-safety-class hardware during natural phenomena events.

Tests and Inspections

Provisions should be made for the periodic tests and inspections of structures, components, and systems within the remote handling system. The tests and inspections should be performed in accordance with applicable codes and standards. Provisions should be made in the design of the equipment to allow testing the following components on a scheduled basis:

1. Electrical Test Capabilities - The design should include provisions to allow testing electrical safety features and controls to verify at least the following:

2. All limit switches are operable and functioning as required.

3. All controlling signals from sensing devices are within specifications.

4. All control switches are operable.

5. All indicating instrumentation is operable and within specified accuracy.

6. All annunciators are operable as specified.

7. All electrical interlocks are operable and functioning as required.

Mechanical Test Capabilities

The design should include provisions to test mechanical safety features and controls to verify at least the following:

1. Proper performance of all load cells.

2. All motors are operable and functioning as required.

3. Hoist load and brake tests.

Special Test Capability

The design should include provisions to perform any special testing that is unique to that equipment.

Design Considerations

General

Most of the remote handling system will be located in the fusion facility. Most remote handling systems' components will be idle during normal plant operation. The area around the fusion device could be subjected to intense electromagnetic, thermal, neutron and gamma radiation environments. Persistent low levels of hydrogen, deuterium, and tritium gases, as well as potential high levels of these gases during unplanned events, should be considered. Activated dust from plasma facing components may be present during maintenance or accident conditions and should be considered. The design should provide for the following general criteria:

1. The remote handling system should be designed such that the operator will not be exposed to a whole body radiation dose rate greater than the current exposure limits. The maximum allowable exposure to tritium must be observed.

2. Allowances should be made for equipment movement so that, in performing intended operations, safe distances can be maintained from personnel in normally accessible work areas.

3. Equipment should be located in areas accessible for operation, testing, inspection, and maintenance. Where this is not possible, a means of safely retrieving the equipment to a safe area should be provided. This requirement must include backup methods of safely disconnecting from radiological hazardous materials, for which the remote equipment is intended.

4. Control panels should be located to afford the operator a full view of the equipment.

5. Equipment should fail safe upon the loss of motive power.

6. Safety features should be incorporated such that failure of one of the drive mechanisms or any component of the equipment will not result in exposure of personnel to radiation in excess of 2.5 mrem/hr while recovering from such failure.

7. Redundancy of critical controls should be provided to prevent single mode control failure of remote or robotic equipment causing unplanned or unanticipated equipment motion.

8. The expected high levels of radio frequency and magnetic interference potentially present should not interfere with control systems on the normal operation of systems.

9. The presence of large quantities of cryogenic materials during both normal and off-normal conditions must be considered in the design of remote equipment.

Radiation Shielding

Design should provide radiation shields between the fusion facility and the remote handling system components in order to reduce exposure to the system components.

Structural Design Codes

The design, fabrication, testing, and inspection of safety-class and safety-significant remote handling equipment should be in accordance with commercial codes and standards applicable to that particular type of equipment. The majority of the systems and components should be considered as non-nuclear-safety (NNS) and should be designed and fabricated to industrial standard requirements outlined in this volume.

Hydrogen Fires and Detonation

Remote handling systems should not initiate a fire or detonation in normal or anticipated off-normal events in the presence of hydrogen gases. Safety-significant remote handling systems and components may fail in a fire or detonation event, but the failure should not degrade the function of an adjacent safety-class system, structure or component. Safety-class equipment should withstand the effects of design basis fire or detonation and retain its basic safety functions.

Expected Hazards

General Requirements

Normal industrial hazards associated with large, automated facilities will be present in a fusion facility. Remote handling facilities should address all of those in their basic design.

In addition, a series of specialized hazards may exist during normal or off normal operation whose combination is unique. The following sections discuss the unique hazards that also must be addressed in the basic system design.

In some off normal excursions it is not expected that remote equipment always continue to be operable, but in all cases it should not contribute to problems through its failure mode and should be recoverable to a safe area.

High Power Equipment in Confined Spaces.

The physical hazards of high power and/or automated systems in restrictive spaces should be addressed. Very high capacity and rigid systems (typical of high precision) will be present, with possibly multiple systems in a common workspace. The hazards associated with this should be addressed.

Plasma Energy

Plasma energy will be present within the fusion facility during normal operation. During off normal excursions the plasma energy will be dissipated into its surroundings, in an extremely short period of time. The rapid collapse of a plasma field will create very large electromagnetic transients and runaway electrons.

Remote equipment either operating or stored within range of the plasma energy must be able to withstand any off normal event that equipment is intended to address. From other off normal events, all critical equipment should be safely recoverable.

Cryogenic

Cryogenic materials in large quantities (e.g. liquid nitrogen, and liquid helium) will be present many areas around the fusion facility. Remote equipment intended to work near or service cryogenic facilities should provide appropriate materials of construction. Seals, wire insulation, etc. should be appropriately chosen or protected.

Radiological Fields

Radiological fields will be normally present at high levels during operation and at decaying levels during outages. During the life of a fusion facility, the outage levels of ionizing radiation are expected to be continually increasing, due to activation of metals.

The primary hazards to the remote handling equipment are high energy ionizing radiation (gamma and some beta), and neutrons. The expected results to the equipment are activation of materials, degradation of non-metallics, and destruction of electronics. The latter is expected to have the most severe effect on the operability of the remote systems.

Electronic systems will be most vulnerable to the direct gamma attack, and, to a lesser extent, damage due to neutrons and runaway electrons. Shielding or remote placement of electronics appropriately should be designed into all systems. Cameras for remote maintenance will require radiation-resistant optics and shielding of electronics.

Radiological Contamination

Radiological contamination concerns include tritium and activated dust from plasma facing components. The tritium contamination is primarily a personnel protection concern that effects the design of systems or modules and is not a direct threat to equipment. However, any high stress components that see a significant tritium environment must be monitored for hydrogen embrittlement.

The direct contamination of equipment from other radiological materials is a potential. Equipment design should allow for rapid decontamination and maintenance to ensure operability and minimize personnel exposure potential.

Magnetic Fields

The magnetic fields associated with the fusion facility magnets is very large. A constant magnetic field will be present near the torus and extremely large transient fields occur during plasma disturbances.

The electrical interference caused by the above field transients should not cause critical electronic failures or unexpected responses from remote handling equipment. A significant level of electromagnetic interference is expected due to routine magnet cycling. The remote equipment must be able to accommodate this interference without damage.

Radio Frequency Fields

High radio frequency (RF) fields are normally present near the torus. Remote handling equipment in this vicinity should be able to accommodate the resultant interference as a normal occurrence.

Hydrogen Isotopes

Hydrogen generation is a potential result of plasma excursions or excursions of other process materials into the plasma, during off normal excursions. Tritium and deuterium are also potentially present during off normal events.

All of the hydrogen isotopes are equally flammable, and when present near the remote handling equipment present an equipment and personnel hazard. The oxidized state of tritium is a particular personnel hazard.

Materials Of Construction

Material Considerations

The acceptable materials of construction for equipment in the vicinity of the fusion facility are affected by the hazards unique to a fusion facility. Major areas of concern are the activation of materials by the intense neutron bombardment, the degradation of materials by all forms of radiation, and the contamination of surfaces from the transfer of radiological materials.

The activation and degradation issues should be addressed by the careful choice of materials, to minimize these effects. The contamination issue should be addressed by careful surface preparation to both prevent the entrapment of radiological materials and facilitate the removal of material.

Replaceable materials should be radiation tolerant to 1 x 10^9 rads of cumulative dosage. Materials that are inaccessible or otherwise difficult to replace should be radiation tolerant to 1 x 10^9 rads cumulative exposure.

Material Requirements

All structural materials used should be chosen for their non oxidizing surface characteristics and resistance to neutron activation, to the extent possible. Stainless steels should be used unless other materials are agreed upon.

Non metallic materials should be chosen for their resistance to neutron activation and to radiological degradation. The failure mode of the materials should not directly cause failures of other systems (e.g. elastomers that become liquids upon radiological exposure). Non metallic materials should not be used that cause degradation of adjoining metallic materials, such as materials that release chlorine.

All metallic and non metallic materials used should be resistant to the chemical, high temperature, low temperature, and other hazards unique to fusion facilities. The specific hazards to be addressed are relative to the equipment's expected location within the fusion facility.

Metal surface characteristics should be smooth and free of paints or coatings, with the exception of strippable coatings used for decontamination. High polish or electropolished surfaces are preferred, due to their ease of decontamination.

All metallic and non metallic materials should be resistant to decontamination processes to be used prior to maintenance. These methods include cleaning with high pressure water, cryogenic materials, and mild acids. Special care must be used to prevent gaps and crevices from entrapping and retaining radiological materials.

Wiring Requirements

Wiring should be resistant to radiological damage to the levels stated in this report. All cabling should be protected from physical hazards expected within the very large fusion facility.

Cabling should be adequately shielded from the high magnetic and radio frequency fields it is expected to encounter. The shielding should be such that the equipment serviced by that cabling is adequately protected from cabling induced interference.

Electrical connectors and wiring methods (per National Electrical Code definitions, or equivalent) should be used to minimize repair or replacement time. Sealed, quick-disconnect connectors should be used wherever possible and all individual wiring methods (e.g. terminal strips) should be avoided. These requirements are intended to minimize the exposure of personnel related to maintenance.

The wiring count from remote equipment to personnel areas should be minimized. The failure potential for remote handling equipment is directly related to the amount of vulnerable wiring, and connectors required from the work area.

Maintenance of Remote Handling Equipment

All remote handling equipment will potentially require maintenance while radiologically activated or contaminated (tritium or other), and should be designed accordingly. Maintenance requirements should allow for personnel using rubber gloves, plastic suits, or similar personal protective equipment. Additionally, the time required to perform maintenance may be directly related to the resultant exposure of personnel to radiological hazards.

Maintenance methods should allow for rapid replacement of components or modules utilizing quick disconnects for all services. Fasteners should be designed for gloved handling and be a captive type if possible.

Contamination Control

Surface contamination from tritium and activated dust should be considered in remote handling system design. The design should allow for rapid surface decontamination, when needed, to ensure function and minimize personnel exposure potential. The design should allow for external liquid contact and should have surface finishes that facilitate decontamination. The potential for tritium entrapment is assumed to be a potential problem for all remote systems.

Assembly and Disassembly Techniques

All systems should be of modular construction, if possible, to facilitate maintenance. Modules can be replaced or relocated to other maintenance facilities with less potential for personnel exposure. Systems for use in highly congested areas must also allow for modular construction to a sufficient degree to allow for access and recovery of components.

Systems or modules of systems should provide for handling by fully protected personnel (e.g. plastic suits) with a minimum of special requirements. Permanent lifting points are desired, and lifting slings (ropes, cables, straps) should be avoided.

Gloved or double gloved hand compatible electrical and service connectors should be used to facilitate connections. Sharp edges or rough surfaces are to be particularly avoided, to prevent compromising protective clothing.

Special Handling Requirements

The handling of typically large and powerful remote equipment in confined spaces and the subsequent maintenance of that equipment should be a design factor. The problem of live system troubleshooting in such an environment is of particular concern. System designs should allow for a methodology of required personnel work without hazard to personnel.

Past Design Practices

Activation Control Methods

The choice of materials of construction is the only known means of minimizing the activation of materials from neutron bombardment. For metallic materials, the over riding structural and contamination concerns require the usage of activating materials, usually stainless steel. For non-metallic materials, if possible, materials of lower activation potential should be utilized, for greases, elastomers, etc.

Contamination Control Methods

Tritium contamination is volumetric in nature and can not be easily eliminated. The contamination by other materials can be minimized by surface condition induced entrapment. Smooth surfaces and no surface coatings will both minimize contamination and simplify decontamination.

Electronics Protection Methods

The very high electrical and magnetic normal and transient fields potentially present in the fusion facility will present a hazard to all electronics systems. Maximum protection should be provided for all interferences that will normally occur as to not interfere with routine operation of remote handling operations. The off normal interferences should not prevent safe retrieval of equipment for repair, and must not introduce unwanted motions; but off normal excursions may result in discontinuation of operation.

Internal Wiring Methods

Wiring through sections and/or modules of remote handling equipment should be provided within the equipment. Externally deployed wiring is expected to present an undesirable hazard to operations. The damage to or damage by externally routed cabling has historically represented an impediment to successful operation. The wiring connectors between sections should also be internal, for operability reasons and to address the requirements shown in the following section.

Operational Requirements

Mode of Operation

The remote handling systems may be operated in the following modes:

Fully Robotic

Telerobotic

Teleoperation

Manual

All systems should be operable in the operational modes of less sophistication than their normal mode. For example, robotic systems should also be operable telerobotic, etc. This requirement is to facilitate recovery from off normal or unanticipated events without personnel entry.

Programmed assistance should be provided in the form of graphics based work cell modeling, or similar, coupled to the movements of any automated system. This should display the location of all known obstacles or objects within a work cell and the present location of the remote system. The control systems should display all programmed motions in the modeled environment, in real time, with display before movement capabilities. This will allow all actions to be tested before operations are started.

Collision Avoidance

The most desirable mode of operation is with active system control to prevent operation in areas of exclusion. In this type of operation, the control system portion of a robotic, telerobotic, or teleoperational system will intervene when commands (either manual or programmed) direct a system into a predetermined exclusion area. The environment can be either statistically modeled, when unchanging, or actively modeled, when dynamic. The active modeling can be vision based, structured light sensed, or similar.

The control system should be the primary means of obstacle avoidance. Active sensors on systems should also be provided where needed to avoid high damage potential collisions.

Multiple Remote Device Coordination

Multiple remote handling systems in the same or overlapping workspace(s) are anticipated. All such systems should have coordinated motions, to prevent their direct interaction. When two systems have an interaction potential, one system will be designated as the lead and the other the follower.

Swing Free Crane Technology

The development of “swing free” technology for cranes or crane systems has been sufficiently demonstrated as having significant economic payback on any crane like system. It should be provided for all remote handling facilities, for which it is appropriate.

Retrieval Requirements

Redundancy of Critical Controls.

All remote handling system controls that, on failure, can cause either (1) a system to perform unintended motions, or (2) a system to fail in a non-recoverable mode, should be redundant, to prevent a common mode failure. This requirement is in addition to normal emergency stops. etc., which required a personnel intervention to be effective.

Remote Release

Remote handling systems must be provided with provision to safely release from highly hazardous loads or materials, in the event of other system failures.

Safe Return of Equipment

Remote handling systems must be recoverable to a safe area for repair, without undo exposure to personnel. The failure of a critical system must not prevent some secondary means of recovering that equipment for repair, if its usage is required to continue operation.

Recommended Design Practices

Potential Safety Functions

Remote handling systems perform a number of safety functions to minimize personnel exposure to radiation and other hazards during normal and off-normal conditions. In addition, system safety functions may be required to prevent or mitigate the off-site consequences of off-normal events. Potential safety functions include:

1. Erect portable radiation shielding panels

2. Place or relocate experimental devices or other equipment in high radiation fields

3. Test or inspect SSCs as necessary to assure performance of safety functions

4. Replace equipment or components in high radiation fields

5. Decontaminate SSCs in preparation for maintenance

6. Install/place diagnostic instruments

7. Install consequence mitigation devices in high radiation fields or otherwise unsafe conditions.

Safety Related-Design Guidance

Remote handling systems may be operated and stored near the fusion device in an area subject to intense magnetic, thermal, neutron and gamma radiation environments. Persistent low levels of hydrogen, deuterium, and tritium gases, as well as potential high levels of these gases during unplanned events, may be present and should be considered in design. Activated dust from plasma facing components may be present during maintenance or accident conditions and should be considered. The design should accommodate the following general guidance:

1. The remote handling system should be designed such that the operator will not be exposed to a whole body radiation dose rate greater than the current exposure limits.

2. Remote handling systems and components should not cause a collision with safety systems or components while performing normal or abnormal plant maintenance. Wiring through sections and / or modules of remote handling equipment should be provided within the equipment.

3. Allowances should be made for equipment movement so that, in performing intended operations, safe distances can be maintained from personnel in normally accessible work areas.

4. Equipment should be located in areas accessible for operation, testing, inspection, and maintenance. Where this is not possible, a means of safely retrieving the equipment to a safe area should be provided. This must include backup methods of safely disconnecting from radiological hazardous materials, for which the remote equipment is intended.

5. Control panels should be located to afford the operator a full view of the equipment.

6. Equipment should fail safe upon the loss of motive power.

7. Safety features should be incorporated such that failure of one of the drive mechanisms or any component of the equipment will not result in exposure of personnel to radiation in excess of 2.5 mrem/hr while recovering from such failure.

8. Redundancy of critical controls should be provided to prevent single mode control failure of remote or robotic equipment causing unplanned or unanticipated equipment motion.

9. The expected high levels of radio frequency and magnetic interference potentially present should not interfere with control systems or the normal operation of systems.

10. The presence of large quantities of cryogenic materials during both normal and off-normal conditions must be considered in the design of remote equipment.

11. Design should provide radiation shields between the fusion facility and the remote handling system components in order to reduce exposure to the system components.

Structural Design

The design, fabrication, testing, and inspection of safety-class and safety-significant remote handling equipment should be in accordance with commercial codes and standards applicable to that particular type of equipment. The majority of the systems and components should be considered as non-nuclear-safety (NNS) and should be designed and fabricated to industrial standard requirements. The design allowables for safety-class or safety-significant remote handling systems and components should be in accordance with codes identified in Section o, Design Guidance for Typical Systems.

Allowable design stresses in mechanical components should provide a factor of safety of 5 when under rated load. Brittle fracture and fatigue during all operation and testing conditions should be design considerations.

Joint and weld details should be designed to prevent lamellar tearing.

Materials

Materials of construction for equipment in the fusion facility are affected by a unique combination of hazards. Major concerns are the activation of materials by the intense neutron bombardment , the degradation of materials by all forms of radiation, and the contamination of surfaces from the transfer of radiological materials.

Activation and degradation issues should be addressed by careful choice of materials. Replaceable materials should be radiation tolerant to 1×10^8 rads of cumulative dosage. Materials that are inaccessible or otherwise difficult to replace should be radiation tolerant to 1 x 10^9 rads cumulative exposure. All structural materials used should be chosen for their non-oxidizing surface characteristics and resistance to neutron activation, to the extent possible. Stainless steels should be used unless other materials are agreed upon. Non-metallic materials should be chosen for their resistance to neutron activation and to radiological degradation. The failure mode of the materials should not directly cause failures of other systems (e.g. elastomers that become liquids upon radiological exposure). Non-metallic materials should not be used that cause degradation of adjoining metallic materials, such as materials that release chlorine.

All metallic and non-metallic materials used should be resistant to the chemical, high temperature, low temperature, and other anticipated hazards. The specific hazards to be addressed are relative to the equipment's expected location within the fusion facility.

The contamination issue should be addressed by careful surface selection and preparation to prevent the entrapment of radiological materials and facilitate the removal of material. Metal surface characteristics should be smooth and free of paints or coatings, with the except of strippable coatings used for decontamination. High polish or electropolished surfaces are preferred, due to their ease of decontamination.

All metallic and non-metallic materials should be resistant to decontamination processes to be used prior to maintenance. These methods include cleaning with high pressure water, cryogenic materials, and mild acids. Special care must be used to prevent gaps and crevices from entrapping and retaining radiological materials.

Electrical

The remote systems should be designed to the equivalent of the National Fire Protection Association Class 1, Division 1 requirements. It is assumed, but not required, that this would be met with the pressurized, interlocked systems approach.

Wiring should be resistant to radiological damage. All cabling should be protected from physical hazards expected within the very large fusion facility.

Cabling should be adequately shielded from the high magnetic and radio frequency fields it is expected to encounter. The shielding should be such that the equipment serviced by that cabling is adequately protected from cabling induced interference.

Electrical connectors and wiring methods (per National Electrical Code definitions, or equivalent) should be used to minimize repair or replacement time. Sealed, quick disconnect type, connectors should be used wherever possible and all individual wiring methods (e.g. terminal strips) should be avoided. These requirements are intended to minimize the exposure of personnel related to maintenance.

The wiring count from remote equipment to personnel areas should be minimized. The failure potential for remote handling equipment is directly related to the amount of vulnerable wiring, and connectors required from the work area.

Tests and Inspections

Provisions should be made to allow testing on a scheduled basis in accordance with applicable codes and standards to verify:

1. All limit switches are operable and functioning as required.

2. All controlling signals from sensing devices are within specifications.

3. All control switches are operable.

4. All indicating instrumentation is operable and within specified accuracy.

5. All annunciators are operable as specified.

6. All electrical interlocks are operable and functioning as required.

7. Proper performance of all load cells.

8. All motors are operable and functioning as required.

9. Hoist load and brake tests.

10. Any special function that is unique to the equipment.

Assembly and Disassembly Techniques

All systems should be of modular construction, if possible, to facilitate maintenance. Modules can be replaced or relocated to other maintenance facilities with less potential for personnel exposure. Systems for use in highly congested areas must also allow for modular construction to a sufficient degree to allow for access and recovery of components.

Systems or modules of systems should provide for handling by fully protected personnel (e.g. plastic suits) with a minimum of special requirements. Permanent lifting points are desired, and lifting slings (ropes, cables, straps) should be avoided.

Gloved or double gloved hand compatible electrical and service connectors should be used to facilitate connections. Sharp edges or rough surfaces are to be particularly avoided, to prevent compromising protective clothing.

Special Handling Requirements

The handling of typically large and powerful remote equipment in confined spaces and the subsequent maintenance of that equipment should be a design factor. The problem of live system troubleshooting in such an environment is of particular concern. System designs should allow for methodology of required personnel work without hazard to personnel.

Design Guidance for Typical Systems

Typical remote handling systems and equipment include:

CCTV (Closed Circuit television)

Electro-Mechanical Manipulator

Cranes

Master Slave manipulators

Hoists

Remote (“Hanford”) Connector System

Specialized Tools (Reach Rods etc.)

Robots

Descriptions and design guidance for each type follows.

Closed Circuit Television (CCTV)

Closed circuit TV is generally used to monitor the remotely performed handling and operations activities. The CCTV equipment should meet the electrical performance standards for monochrome television studio facilities EIA Standard EIA-170-57 Electrical Performance Standards - Monochrome Television Studio Facilities (Nov., 1957) and EIA Standard IETNTS1 Color Television Studio Picture Line Amplifier Output Drawing (Nov., 1977) (Partial Revision of EIA-170). CCTV electrical wiring should be in accordance with NFPA 70, National Electrical Code.

The radiation hardness of the required CCTV system is a function of the particular application, with significant cost and complexity advantages to the non radiation hardened systems, when they are applicable. Each application should define its realistic radiation hardness needs.

Electro Mechanical Manipulator

Design, fabrication, inspection, and testing of Electro-Mechanical Manipulator (EMM) should comply with the requirements of following codes and standards:

Controls	NEMA ICS 1-1993 Industrial Control and Systems: General Requirements
	NEMA ICS 2 through ICS 10 Industrial Control and Systems
Electrical	NFPA 70 National Electrical Code 1993 Edition

Related References:

Design Guide, Manipulators, Auxiliary Tools, and Handling Devices, ANS 11.9, February, 1985.

Force Reflecting Hand Controller for Manipulator Teleoperation, Section 1.3 Final Technical Report NASA Contract # NAS7-1069, Dec. 1991.

Cranes

Design, fabrication, inspection, testing of cranes should be in accordance with the following codes and standards:

Cranes and Hoists: CMAA #70-1975 - “Specifications for Electric Overhead Traveling Cranes, and CMAA #74-1974 - “Specifications for Top Running and Under Running Single Girder Electric Overhead Traveling Cranes and /or ANSI/ASME NOG-1-1989: Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder), Rules for Construction of,

ANSI/ASME B30.16-1993: Overhead Hoists (Underhung), and

ANSI/ASME NUM-1-1996 Rules for Construction of Cranes, Monorails, and Hoists (with Bridge or Trolley or Hoist of the Underhung Type)

Seismic Analysis: CMAA #70 Specification for Electric Overhead Traveling Cranes and /or ANSI/ASME NOG-1-1989: Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder), Rules for Construction of,

Overhead and Gantry Cranes: ANSI/ASME B30.2-1996: Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist)

Hooks: ANSI/ASME B30.10-1993: Hooks

Electrical: NFPA 70: National Electrical Code 1993 Edition, Art 610

IPCEA S-61-402 and IEEE Standard 835-1994, IEEE Standard Power Cable Ampacity Tables

NEMA MG 1-1993 Motors and Generators

NEMA ICS 1-1993 Industrial Control and Systems: General Requirement,

NEMA WC 3-1992 Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (ICEA S-19-1981 Sixth Edition)

ANSI C2 ANSI C2-1997 e: National Electrical Safety Code

Fire Protection: ANSI/NFPA 12 Carbon Dioxide Extinguishing Systems ANSI/NFPA 12

NFPA 72: National Fire Alarm Code

Factory Mutual Approval Guide

The cranes should be provided with all components and appurtenances required for safe operation and handling, in accordance with the Occupational Safety and Health Administration (OSHA) Regulations Section 1910.179 and ANSI B30.2, ANSI B30.1, B30.16 Safety Codes as applicable.

Remote Manipulators

Design, fabrication, inspection and testing of Remote Manipulators should be in conformance with applicable requirements of the following codes and standards:

Hooks - ANSI/ASME B30.10-1993: Hooks, and ANSI/ASME B30.1-1992: Jacks

Hydraulic Power - ANSI/(NFPA/JIC) T2.24.1-1991: Hydraulic Fluid Power - Systems Standard for Stationary Industrial Machinery

Hoists

Auxiliary hoists should be designed and manufactured to comply with the Hoist Manufacturers Institute Specification HMI 100 for Electric Wire Rope Hoists and/or ANSI/ASME HST-4M-1991 (R1996): Performance Standard for Overhead Electric Wire Rope Hoists.

Remote Connector Systems

Remote connector systems (sometimes referred to as “Hanford” type) can be used in the process piping as mechanical jumpers. This type of jumper system allows remote assembly and disassembly of mechanical components such as pumps, valves, pressure vessels, etc. These mechanical jumpers and/or connectors can be remotely operated. The design, fabrication, inspection, and testing of these connector/jumpers and associated equipment should be per manufacturer standards.

Remote connector systems (or jumpers) typically consist of rigid or semi-rigid piping or conduit, for process or electrical service, fitted with remotely coupled end connectors. The remote coupling is accomplished with crane, manipulator, or robot induced locking or unlocking. The assemblies must be designed for routine usage under typically harsh environmental conditions.

The electrical type connector systems must protect the connecting pins or sockets from damage during the coupling operations. The internal wiring and connector pins/sockets must be suitable for their electrical service relative to amperage, shielding requirement, etc. The entire assembly must meet the electrical classification requirements of the particular service. Historically, electrical systems have incorporated hard clamping, seals, and rigid conduits to meet classification requirements as sealed pressurized housings.

Specialized Tools

Specialized tools such as custom designed fixtures , wrenches, reach rods, manipulators etc. can be designed for specific requirements of handling and operation of a particular equipment associated with fusion facility plant. These can be custom designed and fabricated using good engineering and industry practices.

Robots

Industrial robots, custom designed robots, and robotic manipulators can perform certain handling functions. The robot systems consists of four major subsystems: the mechanical unit, drive, control system, and tooling.

The mechanical unit consists of a fabricated structural frame with provisions for supporting mechanical linkage and joints, guides, actuators, control valves, limiting devices, and sensors. The physical dimensions, design, and loading capability of the robot depend upon the application requirements.

Most new robots use electric drives. Pneumatic drives have been used for high speed, non servo robots and are often used for powering tools such as grippers. Hydraulic drives have been used for heavier lift systems, or where severe service is anticipated.

Electric drive systems can provide both lift and/or precision, depending on the motor and servo system selection and design. An AC or DC-powered motor may be used depending on the system design and applications. Hydraulic robots should be provided with operational fluids considered non hazardous (i.e. not flammable or corrosive, negligible radiolytic effects, etc.), to avoid the creation of mixed waste. Mixed waste is the combination of hazardous and radiological components in the same waste form, and is extremely difficult to process.

Most industrial robots incorporate computer or microprocessor-based controllers. These perform computational functions, and interface with and control sensors, grippers, tooling, and other peripheral equipment. The control system also performs sequencing and memory functions associated with communication and interfacing for on-line sensing, branching, and integration of other equipment. Controller programming may be done on-line or from remote, off-line control stations. Robot controllers can have self-diagnostic capability, which can reduce the downtime of robot systems. In addition, the robot controller may be in a control hierarchy in which it receives instructions and reports positions or gives directions. Robot manufacturers typically use proprietary language for programming robot controllers and systems.

Tooling is manipulated by the robot to perform the functions required for the application. Depending on the application, the robot may have one functional capability, such as making spot welds or spray painting. These capabilities may be integrated with the robots mechanical system or may be attached at the robot's wrist-end effector interface. Alternatively, the robot may use multiple tools that may be changed manually or automatically during a work cycle.

Table II-5 following shows Standards and Codes used for robot design, fabrication and safety requirements.

Table 5 Standards and codes for robots.

	Group	Standard	Subject
1.	ANSI/RIA	R15.06-1992	Robotic Industries Association standards for Industrial robots and robot systems
2.	BSR/RIA	BSR/RIA R15.06-1992	(ANSI) Board of Standards Review proposed standard for industrial robots and robot systems
3.	ANSI/RIA	R15.02-1990	Human engineering design criteria for hand-held robot control pendants
4.	OSHA	Pub. 2254 (revised)	Training requirements in standards and training guidelines
5.	NIOSH	Pub. 88-108	Safe maintenance guidelines for robotics workstations
6.	OSHA	Pub. 8-1.3, 1987	Guidelines for robotics safety
7.	OSHA	29 CFR 1910.147	Control of hazardous energy source) (lockout/tagout final rule)
8.	AFOSH	127-12, 1991	Occupational safety machinery
9.	OSHA	DOE/EH-0353P	OSHA Technical Reference Manual

Section II References

10CFR50(A)	10CFR50, Appendix A, "General Design Criteria for Nuclear Power Plants," specifically criteria 1, 13, 19, 20, 22, 23, 24 and 64.
10CFR50(I)	10CFR50, Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low As Reasonably Achievable" for Radioactive Material in Light Water-Cooled Nuclear Power Plant Effluents."
10CFR820	Procedural Rules for DOE Nuclear Activities
10CFR830	Nuclear Safety Management
10CFR835	Occupational Radiation Protection
ACI 318	ACI 318, "Building Code Requirements for Reinforced Concrete," 1989
ACI 349	ACI 349, "Code Requirements for Nuclear Safety Related Concrete Structures and Commentary," 1985
AISC 84	American Institute of Steel Constructors (AISC) standard N690, "Specification for Design, Fabrication and Erection," 1984.
AISC 86a	AISC, "Manual of Steel Construction and Specification for the Design, Fabrication and Erection of Structural Steel for Buildings," 9 Edition, 1986
AISC 86b	AISC-LRFD, "Load and Resistance Factor Design Specification for Structural Steel Buildings," 1 Edition, 1986
AISC N690	American Institute of Steel Constructors (AISC) standard N690, "Specification for Design, Fabrication and Erection," 1984.
ANSI 83.	American National Standard Institute/American Nuclear Society (ANSI/ANS), ANSI/ANS 51.1-1983, "Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants."
ANSI 84	ANSI/AISC N690, "Nuclear Facilities Steel Safety Related Structures Design, Fabrication and Erection," 1984
ANSI-89	ANSI/IEEE C37.010-1979 (R1989) "Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (includes supplements ANSI/IEEE C37.010b and C37.010d)
ANSI 90	ANSI/RIA R15.02-1-1990, "Human Engineering Design Criteria for Hand-Held Robot Control Pendants"

ANSI-92	ANSI/ANS 3.8.5-1992 "Criteria for Emergency Radiological Field Monitoring, Sampling, and Analysis"
ANSI 92b	ANSI/RIA R15.06-1992, "Industrial Robots and Robot Systems - Safety Requirements"
ANSI 93	American National Standards Institute (ANSI) ANSI/ASME Standard B31.3, "Chemical Plant and Petroleum Refinery Piping," 1993.
ANSI-95	ANSI/ANS 3.8.6-1995 "Criteria for Conduct of Offsite Radiological Assessment for Emergency Response for Nuclear Power Plants"
ANSI-96	"Rules for Construction of Cranes, Monorails, and Hoists (with Bridge or Trolley or Hoist of the Underhung Type," ANSI/ASME NUM-1-1996.
API-620	American Petroleum Institute (API) API-620, "Design and Construction of Large, Welded, Low-Pressure Storage Tanks, Ninth Edition," 01-Feb-96
API-650	American Petroleum Institute (API), API-650, "Welded Steel Tanks for Oil Storage," 1993.
ASCE 80	"Structural Analysis and Design of Nuclear Plant Facilities," ASCE, Manual No. 58, 1980
ASCE 93	ANSI/ASCE, "Minimum Design Loads for Buildings and Other Structures," 7-93, ASCE
ASHRAE 91	ASHRAE Handbook of HVAC Application, 1991, Chapter 24 entitled "HVAC for Nuclear Facilities."
ASHRAE	ASHRAE, "Design Guide for Department of Energy Nuclear Facilities," ISBN 1-883413-03-6
ASME 89a	ASME N509, "Nuclear Power Plant Air-Cleaning Units and Components" - 1989
ASME 89b	ASME N510, "Testing of Nuclear Air Treatment Systems," 1989
ASME 89c	American Society of Mechanical Engineers (ASME), "Rules for Inservice Inspection of Nuclear Power Plants," Section XI, 1989.
ASME 89d	ASME Boiler and Pressure Vessel Code Section IX, "Welding and Brazing Qualification," 1989 Edition
ASME 91	ASME Papers:
	91-GT-366, "Reliability, Availability, and Maintainability Usage in the Development of the 501F Combustion Turbine and Auxiliaries."

	92-GT-208, "Reliability Measurements for Gas Turbine Warranty Situations."
	92-GT-236, "Operating Experience and Site Performance Testing of the CW251B12 Gas Turbine Engine."
ASME 93a	American Society of Mechanical Engineers (ASME), "Boiler and Pressure Vessel Code," 1992 Edition with 1993 Addenda.
ASME 93b	ANSI/ASME, "Chemical Plant and Petroleum Refinery Piping," Standard B31.3, 1993
ASME 93c	ASME AG-1, "Code on Nuclear Air and Gas Treatment," 1993
ASME 95	ANSI/ASME B40.5-1995, "Snubbers"
ASTM-95	ASTM D5537-94 "Heat Release, Flame Spread and Mass Loss Testing of Insulating Materials Contained in Electrical or Optical Fiber Cables When Burning in a Vertical Cable Tray Configuration," American Society for Testing and Materials, West Conshohocken, PA,1994.
AWWA D-100	American Water Works Association (AWWA), AWWA D-100, "Welded Steel Tanks for Water Storage," 1984, with 1989 Addendum A.
Burchsted 76	A. Burchsted, A. B. Fuller, and J. E. Kahn, "Nuclear Air Cleaning Handbook," ERDA 76-21, March 1976
CMAA	CMAA #70-1975 - "Specifications for Electric Overhead Traveling Cranes and CMAA #74-1974 - "Specifications for Top Running and Under Running Single Girder Electric Overhead Traveling Cranes, Crane Manufacturers Association of America, 1326 Freeport Road, Pittsburgh, PA, 15238.
DOD 86	"Seismic Design Guidelines for Essential Buildings, a supplement to Seismic Design for Buildings," Army TM5-809-10-1, Navy NAVFAC P-355.1, Air Force AFM 88-3, Tri-Service Manual, Departments of Army, Navy and Air Force, Washington, D.C., February 1986
DOE 1020	DOE Standard, "Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities," DOE-STD-1020-94, April 1994
DOE 1021	DOE Standard, "Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components," DOE-STD-1021-94
DOE 3003	DOE-DP-STD-3003-93, Back-up Power Sources for DOE DP facilities
DOE 5480.11	DOE Order 5480.11, "Radiation Protection for Occupational Workers, June, 1990.
DOE 5480.23	DOE Order 5480.23, "Nuclear Safety Analysis Reports"

DOE 5480.28	DOE Order 5480.28, "Natural Phenomena Hazards Mitigation," January 15, 1993
DOE 5480.4	DOE Order 5480.4, Environmental Protection, Safety and Health Protection Standards," May 15, 1984.
DOE 5632.1C	DOE Order 5632.1C, "Protection and Control of Safeguards and Security Interests"
DOE 5633.3B	DOE Order 5633.3B, "Control and Accountability of Nuclear Materials," September 7, 1994.
DOE 6430.1A	DOE Order 6430.1A, General Design Criteria, Division 13, 1989.
EIA-170	"Electrical Performance Standards - Monochrome Television Studio Facilities," Electronic Industries Association, November, 1957
EIA-IETNTS1	"Color Television Studio Picture Line Amplifier Output Drawing," Electronic Industries Association, Nov., 1977 (Partial Revision of EIA-170)
HEI 80	Heat Exchanger Institute, Inc., "Standard for Power Plant Heat Exchangers," 1/e, Cleveland, Ohio, 1980.
HIS	Hydraulic Institute Standards, Cleveland, Ohio.
HMI 100	"Specification for Electric Wire Rope Hoists," Hoist Manufacturers Institute, 8720 Red Oak Blvd. Suite 201 - Charlotte, NC 28217
Hord 78	Hord, J., "Is Hydrogen Safe?" *International Journal of Hydrogen Energy*, Vol. 3, pp. 157-176, 1978.
IEC 964	Design for Control Rooms of Nuclear Power Plants, (1989-03) International Electrotechnical Commission 1989.
IEEE 80	IEEE 80-1986, "Guide for Safety in AC substation Grounding"
IEEE 115	IEEE 115-1995, "Test Procedures for Synchronous Machine"
IEEE 142	IEEE 142-1991, "IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems"
IEEE 308	IEEE 308-1991, "IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations" (see also Regulatory Guide 1.6)
IEEE 317	IEEE 317-1983, "IEEE Standard for Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations"
IEEE 323	IEEE 323-1983 "Qualifying Class 1E Equipment for Nuclear Power Generating Stations," 1983.

IEEE 336	IEEE 336-1985, "IEEE Standard Installation, Inspection and Testing Requirements for Power, Instrumentation and Control Equipment at Nuclear Facilities"
IEEE 338	IEEE 338-1987, "IEEE Standard Criteria for the Periodic Surveillance Testing of Nuclear Power Generating Station Safety Systems" (see also Regulatory Guide 1.118)
IEEE 344	IEEE 344-1987 "IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations"
IEEE 352	IEEE 352-1987, "IEEE Guide for General Principles of Reliability Analysis of Nuclear Generating Station Safety Systems
IEEE 379	IEEE 379-1994, "IEEE Standard Application of the Single Failure Criterion to Nuclear Power Generating Station Safety Systems" (see also Regulatory Guide 1.53)
IEEE 382	IEEE 382-1996 "IEEE Standard for Qualification of Actuators for Power-Operated Valve Assemblies with Safety-Related Functions for Nuclear Power Plants," (see also regulatory Guide 1.73)
IEEE 383	IEEE 383-1974 "IEEE Standard for Type Testing of Class 1E Electrical Cables, Field Splices, and Connections for Nuclear Power Generating Stations"
IEEE 384	IEEE 384-1992 "IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits," (see also Regulatory Guide 1.75)
IEEE 386	IEEE 386-1995 "IEEE Standard for Separable Insulated Connector systems for Power Distribution systems Above 600 V"
IEEE 387	IEEE 387-1995 "IEEE Standard Criteria for Diesel Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations," (see also Regulatory Guide 1.9)
IEEE 420	IEEE 420-1982 "IEEE Standard for the Design and Qualification of Class 1E Control Boards, Panels, and Racks Used in Nuclear Power Generating Stations"
IEEE 450	Recommended Practice for Maintenance Testing and Replacement of Large Lead Storage Batteries for Generating Stations and Substations (see also Regulatory Guide 1.129)
IEEE 485	IEEE 485-1983 "IEEE Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations"

IEEE 577	IEEE 577-1976 “IEEE Standard Requirements for Reliability Analysis in the Design and Operation of Safety Systems for Nuclear Power Generating Stations”
IEEE 603	IEEE 603-1991 “IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations”
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IEEE 829	IEEE 829-1983 “IEEE Standard for Software Test Documentation”
IEEE 830	IEEE 830-1993 “IEEE Recommended Practice for Software Requirements Specifications”
IEEE 1012	IEEE 1012-1986 “IEEE Standard for Software Verification and Validation Plans”
IEEE 1016	IEEE 1016-1987 “IEEE Recommended Practice for Software Design Descriptions”
IEEE 1042	IEEE 1042-1987 “IEEE Guide to Software Configuration Management”
IEEE 1063	IEEE 1063-1987 “IEEE Standard for Software User Documentation”
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NFPA 204M: NFPA 204M, "Smoke and Heat Venting," National Fire Protection Association, 1991.

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NUREG-0800 NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," Chapter 7.1

RG 1.6 Regulatory Guide 1.6, "Independence Between Redundant Standby (On-Site) Power Sources and Between Their Distribution Systems

RG 1.30 Regulatory Guide 1.30, "Quality Assurance Requirements for the Installation, Inspection, and Testing of Instrumentation and Electric Equipment," August 1972.

RG 1.47 Regulatory Guide 1.47, "Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems," US Nuclear Regulatory Commission, May 1973.

RG 1.53 Regulatory Guide 1.53, "Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems"

RG 1.63	Regulatory Guide 1.63, “Electric Penetration Assemblies in Containment Structures for Nuclear Power Plants.” U.S. Nuclear Regulatory Commission, February 1987.
RG 1.75	Regulatory Guide 1.75, “Physical Independence of Electric Systems,” US Nuclear Regulatory Commission, September 1978.
RG 1.89	Regulatory Guide 1.89, “Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants”
RG 1.100	Regulatory Guide 1.100, “Seismic Qualification of Electric and Mechanical Equipment and Mechanical for Nuclear Power Plants”
RG 1.105	Regulatory Guide 1.105, “Instrument Setpoints for Safety-Related Systems”
RG 1.131	“Qualification Tests of Electric Cables, Field Splices and Connections for Light-Water Cooled Nuclear Power Reactors”
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RG 1.140	Regulatory Guide 1.140, “Design, Testing and Maintenance Criteria for Normal Ventilation Exhaust System Air Filtration and Absorption Units of Light Water Cooled Nuclear Power Plants,” US Nuclear Regulatory Commission, October 1979.
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SECTION III

ADMINISTRATIVE AND OPERATIONAL TECHNIQUES

CONCEPT OF OPERATIONS

Purpose

The purpose of this section is to establish a conduct of operations program which should result in improved quality and uniformity of operations.

Supplemental Guidance

Appendix A provides a listing of guidance documents that may be useful in developing the site specific conduct of operations program.

Policy

Fusion facilities should have a policy that assures: operations are managed, organized and conducted in a manner to assure an acceptable level of safety; and operators have procedures in place to control the conduct of their operations.

Guidance

Experience has shown that the better operating facilities have well defined, effectively administered policies and programs to govern the activities of the operating organization, including the areas described by these guidelines. The guidance is based upon well developed industrial operations practices. They are written to be flexible, so that they encompass the range of facilities and operations.

Each fusion facility should develop a conduct of operations program which covers the following topics, as appropriate, using a graded approach. Specifics for each of the sections can be found in the references cited in Appendix A.

Operations Organization and Administration

The organization and administration of operations should ensure that a high level of performance is achieved through effective implementation and control of operations activities. Operations should establish a policy of excellence under which the facility is operated and clear lines of responsibility for normal and emergency conditions are established. Policies, resources, monitoring and accountability for operations should be established to meet this guideline.

Shift Routines and Operating Practices

Standards for the professional conduct of operations personnel should be established and followed so that the operator performance meets the expectations of facility management. Specifically, requirements for watch standing practices and routine shift practices should be established.

Control Area Activities

This area should address important elements of control area activities that are necessary to support safe and efficient facility operations.

Communications

This area should address important aspects of providing accurate transmission of information within the facility.

Control of On-Shift Training

This area should address the control of training activities by operations personnel in the area of hands-on operational experience.

Investigation of Abnormal Events

A process for the investigation of abnormal events should ensure that facility events are thoroughly investigated to assess the impact of the event, to determine the root cause, and to identify corrective actions to prevent recurrence of the event.

Notifications

A process to notify appropriate personnel and agencies should be employed by the facility for issues affecting public health and safety.

Control of Equipment and System Status

A process should be in effect to ensure that the facility configuration is maintained in accordance with the design requirements and that the operating shift knows the status of the equipment and systems.

Lockouts and Tagout

A process should be in effect provide a method for equipment status control through component tagging or locking which protects personnel from injury, protects equipment from damage, maintains operability of plant systems and maintains the integrity of the physical boundaries of plant systems.

Independent Verification

An independent verification process should be established to assure that the correct position of components such as valves, switches and circuit breakers are maintained to provide a high degree of reliable operations.

Logkeeping

Requirements for operations records should be established which includes narrative logs of the facilities status and a history of facility operations.

Operations Turnover

A method for shift turnovers should be established so that oncoming operators are provided with an accurate picture of the overall facility status.

Operations Aspects of Facility Chemistry and Unique Processes

Processes should be established for monitoring chemistry and unique process parameters to promote maximum component life and reliable operations.

Required Reading

A required reading process should be established so that operations personnel are made aware of important information that is related to job assignment.

Timely Orders to Operators

Plant management should establish a means to communicate short-term information and administrative instructions to operations personnel in a timely manner.

Operations Procedures

Operations procedures should be established to provide appropriate direction to ensure that the facility is operated within its design bases and should be effectively used to support safe operation of the facility.

Operator Aid Postings

An operator aid process should be established to ensure that operator aids that are posted are current, correct, and useful.

Equipment and Pipe Labeling

A well established and maintained equipment labeling process should be established to help ensure that facility personnel are able to positively identify equipment they operate.

EMERGENCY PREPAREDNESS

Purpose

To establish requirements for Emergency Management Programs for operational emergencies involving fusion facilities. Fusion facilities should develop, using a graded approach, an emergency management program consistent with the determined level of risk at the facility.

Supplemental Guidance

Appendix B provides a listing of guidance documents that may be useful in developing the site specific emergency management program.

Appendix C provides a listing of definitions used in this section of the document.

Concept of Operations

The Emergency Management System (EMS) should include a graded approach to emergency management concepts such as planning, preparedness, and response. "Planning" includes the development and preparation of emergency plans and procedures and the identification of necessary personnel and resources to provide an effective response. "Preparedness" includes the training of personnel, acquisition and maintenance of resources, and exercising of the plans, procedures, personnel, and resources essential for emergency response. "Response" represents the implementation of planning and preparedness during an emergency and involves the effective decisions, actions, and application of resources that must be accomplished to mitigate consequences and recover from an emergency.

Operational Emergency Event Classes

Emergencies should be characterized as one of the Operational Emergency classes (e.g., Alert, Site Area Emergency, or General Emergency). Emergency Action Levels (EALs), the specific criteria used to recognize and categorize events, should be developed for the spectrum of potential operational emergencies consistent with the hazards assessment.

Alert

An event in progress or having occurred which involves an actual or potential substantial reduction of the level of safety of the facility. Limited offsite releases of radioactive materials may occur. For other toxic materials, offsite releases are not expected to exceed applicable, permissible limits. The purpose of an Alert level is to assure that onsite and offsite emergency response personnel are properly advised and available for activation if the situation becomes more serious, to initiate and perform confirmatory monitoring as required, and to assure appropriate notification of emergency conditions to the responsible organizations.

Site Emergency

An event in progress or having occurred which involves actual or likely major failures of facility functions which are needed for the protection of onsite personnel, the public health and safety, and the environment. Significant releases offsite of radioactive material are likely or are occurring. For other toxic materials, offsite releases have the potential to exceed applicable permissible limits. The purpose of the site emergency level is to assure that emergency control centers are manned, appropriate monitoring teams are dispatched, personnel required for determining onsite protective measures are at duty stations, predetermined protective measures for onsite personnel are initiated, and to provide current information and consultation with offsite officials and organizations.

General Emergency

An event in progress or having occurred which involves actual or imminent substantial reduction of facility safety systems. Releases offsite of radioactive materials are occurring or expected to occur and exceed allowable limits. Offsite releases of other toxic materials are expected to exceed applicable permissible limits. The purpose of the general emergency level is to initiate predetermined protective measures for onsite personnel, the public health and safety, and the environment, and to provide continuous assessment of emergency conditions and exchange of information both onsite and offsite. Declaration of a general emergency will initiate major activation of resources required to effectively mitigate the consequences of emergency conditions and assure the protection of onsite personnel, the public health and safety, and the environment to the extent possible.

Emergency Plans and Procedures

An emergency plan and procedures should be developed for the fusion facility. The plan is a documented "concept of operation" that describes the essential elements of advance planning that have been considered and the provisions that have been made to mitigate emergency situations. The plan should incorporate information about the emergency response roles of supporting organizations and agencies and should be consistent with a graded approach to managing an incident. Programs must consist of special emergency plan implementing procedures (e.g., EALs, event categorization, notification, Emergency Operations Center operation) as well as other procedures currently in use (e.g., equipment operation, chemistry controls, radiological monitoring, and maintenance) which would be utilized in, or associated with, emergency response activities.

Procedures must be consistent and compatible with the emergency plan. Emergency procedures must contain the detailed information and the specific instructions needed to carry out the emergency plan during a drill, exercise, or actual emergency.

Procedures must maintain consistency with the general graded approach and nomenclature of emergency planning and preparedness elements within Federal and State agencies, private industry, tribal, and local authorities.

Hazards Assessment

Hazards assessments provide the technical basis for emergency management programs. The extent of emergency planning and preparedness required for a particular facility directly corresponds to the type and scope of hazards present and the potential consequences of accidents or events. A hazards assessment includes identification of any hazards and targets unique to a facility, analyses of potential accidents or events, and evaluation of potential accident or event consequences.

Methodology, models, and evaluation techniques used in the hazards assessment should be documented. Also, the hazards assessment should include a determination of the size of the Emergency Planning Zones where applicable, i.e., the area surrounding the facility for which special planning and preparedness efforts are required to ensure that prompt and effective protective actions can be taken to minimize the risk to workers, the general public, and the environment.

Other hazards assessments are documented in Material Safety Data Sheets; Safety Assessments; Spill Prevention, Control, and Countermeasure Plans; Pre-Fire Plans; Environmental Assessments and Impact Statements (EAs and EISs); ERPG's; Severe Accident Analyses; and the Emergency and Hazardous Chemical Inventory Forms and Toxic Chemical Release Forms, prepared pursuant to the requirements of the Emergency Planning and Community Right-to-Know Act (SARA Title III).

Emergency Response Organization

An emergency response organization should have overall responsibility for the initial and ongoing response to, and mitigation of, an emergency, and must perform, but not be limited to, the following functions:

Event categorization, determination of the emergency class, notification, provision of protective action recommendations, management and decision making, control of onsite emergency activities, consequence assessment, medical support, public information, activation and coordination of onsite response resources, security, communications, administrative support, and coordination and liaison with offsite support and response organizations;

Consist of an adequate number of experienced and trained personnel, including designated alternates, for timely performance of the functions identified above;

Assign emergency response responsibilities and tasks to specific individuals identified by title, or position; and

Integrate local agencies and organizations which would be relied upon to provide onsite response services and include those contractor and private organizations that may be relied upon to provide specialized expertise and assistance to all emergency planning, preparedness, and readiness assurance activities.

Offsite Response Interfaces

Provisions should be in place for interface and coordination with Federal, state, tribal, and local agencies and organizations responsible for offsite emergency response and for protection of the environment and the health and safety of the general public. Interrelationships with offsite organizations should be prearranged and documented.

Notification

Provisions should be in place for prompt initial notification of emergency response personnel and response organizations, including appropriate offsite elements and for continuing effective communication among the response organizations throughout an emergency.

Consequence Assessment

Provisions should be in place to adequately assess the actual or potential onsite and offsite consequences of an emergency and include:

1. Timely initial assessment of the actual or potential consequences.

2. Integration of consequence assessment with the process for categorization of an event as an emergency.

3. Monitoring and evaluation of the specific indicators necessary to continually assess the consequences of emergency events.

4. Coordination with Federal, state, tribal, and local organizations to locate and track hazardous materials released to the environment.

Protective Actions

Where applicable, provisions should be in place for predetermined actions to be taken in response to emergency conditions to protect onsite personnel and the public and include:

1. Protective Action Guides (PAGs) and Emergency Response Planning Guidelines (ERPGs).

2. Control, monitoring, and maintenance of records of onsite personnel exposures to hazardous materials;

3. Accountability for facility personnel of emergency determination, and timely sheltering and/or evacuation of workers, in the affected area.

4. Radiological and/or hazardous material decontamination of workers and equipment evacuated from the site;

5. Determination of the area surrounding the specific facility actually affected by an Operational Emergency; and

6. Timely recommendation to appropriate offsite organizations of protective actions, such as sheltering and/or evacuation, for the general public, where applicable.

Medical Support

Provisions should be in place for medical support for workers, including those with radiological and/or hazardous material contamination, and include:

1. Immediate, onsite first aid and emergency medical treatment capability;

2. Transportation of injured onsite personnel to onsite or offsite medical facilities, as appropriate; and

3. Documented arrangements with onsite and offsite medical facilities to accept and treat contaminated, injured personnel.

Recovery and Reentry

Provisions should be made for recovery and reentry from an operational emergency and reentry into the affected facility. The approach and general procedures for recovery include: decision making and communications associated with termination of an emergency; dissemination of information to offsite organizations regarding the emergency and relaxation of public protective actions; establishment of a recovery organization; and establishment of general criteria for resumption of normal operations.

The means must exist for estimating dosage and for protecting workers and the general public from hazardous exposure during recovery and reentry activities.

Public Information

An emergency public information program should be developed to ensure that necessary public affairs actions are planned, coordinated and taken as an integral part of the total emergency response effort.

Emergency Facilities and Equipment

Facilities and equipment, adequate to support emergency response, should be established and maintained as follows:

1. An Emergency Operations Center (EOC) should be established from which the emergency response organization assesses, evaluates, coordinates, and directs emergency response activities and communicates within DOE and offsite response organizations.

2. The staffing, operation, and response activities pertaining to the EOC, should be predetermined and documented in procedures for a timely and coordinated overall emergency response.

3. Primary and backup means of communications should be available.

4. Adequate equipment and supplies should be available and operable for emergency response personnel to carry out their respective duties and responsibilities.

5. Training

6. Training must be provided to effected workers regarding operational emergencies, and specialized training must be conducted for workers and be available to offsite emergency response organizations.

7. Training should be provided annually to workers who may have to take protective actions (e.g., assembly, evacuation) in the event of an emergency.

8. A training program should be in place for the instruction and qualification of personnel (i.e., primary and alternate) comprising the facility emergency response organization to include initial training and bi-annual retraining for both onsite and offsite incidents, including transportation incidents.

9. Retraining should include training on weaknesses detected during drills and exercises, changes to plans and procedures, and lessons learned from emergencies at other facilities.

10. Offsite emergency response organizations should be offered facility-specific orientation training and information on hazards and emergency response bi-annually.

Drills and Exercises

A coordinated program of drills and exercises should be an integral part of the emergency management program as follows:

Drills

Drills should be used to develop and maintain personnel skills, expertise, and response capability. Drills should be of sufficient scope and frequency to ensure adequate response capability in applicable areas. Drills should include emergency response activities such as notification, emergency communication, fire, medical emergencies, hazardous material detection and monitoring, environmental sampling and analyses, security, personnel, accountability, evacuation, emergency categorization, decontamination, facility activation, public information, and health physics. There should be at least one drill per year to train in notification and emergency communications with offsite authorities.

Exercises

"Table Top" exercises should be conducted annually to test and demonstrate an integrated emergency response capability.

A full participation exercise should be conducted bi-annually in accordance with established plans and implementing procedures. A controller and evaluation group should be established for each exercise to ensure that events occur which address the objectives of the exercise. A critique process should be conducted for each exercise to provide accomplishments and shortcomings discovered during the exercise;

Each member of the functional emergency response organization should participate in a "table top" drill and/or exercise at least annually to demonstrate proficiency in assigned response duties.

TRAINING AND QUALIFICATION REQUIREMENTS

Purpose

The purpose of this section is to establish the staffing, training, qualification, and certification (herein called training and qualification) requirements for personnel at fusion facilities. It contains requirements that must be included in training and qualification programs using a graded approach based upon the hazards of the facility. The requirements are based on governmental and related industry standards.

Supplemental Guidance

Appendix D provides a listing definitions used in this section of the document. It also provides a listing of guidance documents that may be useful in developing the site specific training and qualification programs.

Administrative Requirements

General Facility Requirements

The responsibilities and authority of individuals must be specific, and appropriate plans and procedures must be developed and implemented to assure that the objectives of this program are met. Each fusion facility should:

1. Develop and implement a training and qualification program using a graded approach based upon the hazards of the facility;

2. Prepare, approve and implement a training plan that sets forth the staffing, training, and qualification requirements.

Training Organization

Each facility should establish an organization that is responsible for the training and qualification of facility personnel. The duties, responsibilities, qualifications and authority of training organization personnel should be documented, and managerial responsibilities and authority clearly defined.

Contracted Personnel

Each facility should establish training and qualification criteria for contracted personnel used in facility organizations:

1. Contracted personnel who act as regular employees in the organization should complete the same training and qualifications programs required of regular employees, as appropriate to the job.

2. Contracted personnel who perform specialized, temporary or other scope-of-work functions should be qualified by their contracting company to perform their assigned jobs. The facility should provide any facility-unique training that may be required.

When contracted personnel used do not meet the training and qualification criteria established, their work should be overseen by qualified personnel.

Facility Training Plan

The facility training plan is the document that provides the overall description of facility staffing, training, qualification, and certification programs. This plan should be prepared to address the following:

1. Initial and continuing training programs, including maintenance of training;

2. Training and qualification programs for personnel who require formal qualification and certification; and

3. Examination program requirements for qualification and certification.

The facility training plan should be supplemented, as needed, with written procedures that address, as a minimum: examination and operational evaluation development, approval, security, administration, and maintenance; administration of medical requirements; and recordkeeping requirements.

Personnel Selection and Staffing

Personnel Selection

Each facility should establish a process for the selection and assignment of personnel. The personnel selection process should include an evaluation of their education, experience, previous training, and existing job skills and capabilities. It is the responsibility of management to assure that personnel assigned to a specific job function have the requisite background and/or receive sufficient qualification training for the job.

In those cases where an individual does not meet the literal experience requirements for the position, consideration should be given to the collective experience of the work unit. Individuals who do not meet the experience requirements for a position may be assigned to that position provided the experience of the overall work unit is considered balanced and strong. In such cases, the decision to assign the individual should be documented and approved by facility management.

Entry-level education and experience minimums are provided in Appendix D. In addition, each facility should describe in a procedure methods for accepting alternatives to the specified education and experience minimums. Examples of alternatives are provided in Appendix D.

Personnel Staffing

The following categories of facility staff are identified as requiring training, qualification, or certification in order to perform job functions [see Appendix D for definitions]. If qualification or certification is identified, it should be documented in writing.

1. Operators and their Supervisors - those who operate primary systems (such as those that produce the fusion reaction) require certification. Those who operate other systems (such as auxiliary systems) require qualification.

2. Technicians - training

3. Maintenance Personnel - training

4. Supervisors and Managers - training

5. Operations and Facility Support Functions - those who perform engineering or analytical support functions require training. Those who perform specialized support functions (such as quality control, radiation control, or emergency response) require qualification.

Training Requirements

Training Matrices

The program for personnel who require only training is typically detailed in a training matrix prepared in accordance with a facility procedure. This matrix should include the training requirements as appropriate to the job function.

Qualification and Certification Procedures

Positions that require formal qualification or certification should be documented in a written procedure that outlines the qualification or certification requirements.

Management Training

Personnel with management responsibilities should receive training in managerial, communication, and interpersonal skills that is appropriately tailored to the organization that they supervise. In disciplines where this training is not included in the manager's university or college curricula (such as the scientific and engineering disciplines), the plan should require such training as part of the functional responsibilities of those managers.

Training Exceptions

Initial training programs are developed for personnel with entry-level knowledge and skills. In some cases, personnel may already possess the requisite knowledge and skills, and may be excepted from training. The basis for exceptions includes education, prior training, experience, or challenge testing.

Job Incumbency may also be used as a basis for exception for entry-level training and examination requirements based upon the individual’s incumbency prior to the development of training and examination requirements and the cognizant manager’s verification of technical competency in the stated job function.

Personnel who develop or present training programs should receive training credit for their activities and are excepted from completing this training as “participants.”

As a general rule, exceptions to “hands-on” training or “on the job” may not be granted due to the unique nature of such training, except for those individuals who develop or present such training.

Exceptions to training (other than by challenge testing or material development/presentation) should be documented in writing and approved by the facility Training Manager, as recommended by facility line management. Such documentation should include the name of the individual, the specific training for which exception is taken, and full and detailed justification for the exception. In no case should exceptions be granted for required qualification or certification examinations for non-job incumbents.

Training Programs

Training programs at fusion facilities should consist of regulatory-driven training (such as OSHA training) and position-specific training (procedures and methods associated with the job function), to the extent needed.

Training Required for Facility Access

Each facility should define the minimum training required access (escorted and unescorted). It should be recognized that completion of access training does not automatically grant access authorization for the facility. Facility management retains the right to authorize or deny access, in accordance with approved procedures.

Minimum training required for facility access should include General Employee Training and Radiation Safety Training.

Initial Training Requirements

The training matrix should include required and recommended entry-level training for the job function. Each line manager should identify initial training requirements, training priorities, and the sequence of training for personnel under their supervision who require only training.

The qualification or certification procedure, as applicable, should identify required and recommended entry-level training for the job function. Such procedures should include both technical (subject matter) and training evaluators reviews.

Continuing Training Requirements

Continuing training programs should be implemented to maintain and enhance the proficiency of personnel. A required reading program may also be used, when appropriate, to accomplish continuing training.

Maintenance of Training

Continuing training includes topics which require renewal. The following is recommended:

1. Two (2) year renewals for General Employee Training and Radiological Health and Safety programs.

2. “Just in Time” training for facility changes, “Lessons Learned” training and when a governing document changes, as in the case of procedures.

Unless specified by a regulatory rule, renewal intervals should be determined by each facility based upon experience with the topic. Personnel should maintain training in those topics required to support their job function. If an individual does not maintain training, only that part of their job covered by the lapsed training is impacted.

Qualification Requirements

Qualified Operators and Supervisors

The qualification program for qualified operators and supervisors should be detailed in a procedure that addresses the following elements of this section. Upon completion of program requirements, the candidate may be granted qualification.

Education and Experience

Minimum education and experience requirements should be established. Recommended requirements are detailed in Appendix D.

Specific Training

Specific training requirements should be detailed in a training curriculum developed for the qualification procedure. The training curriculum should prescribe the minimum training required for qualification, and should include classroom , practical and on-shift.

Medical Examinations

Medical examination requirements are based upon the physical demands imposed by the job function. If required, medical examinations are conducted at periodic intervals not to exceed two years. Medical examination criteria should be detailed in the qualification procedure.

Written Examinations

Written examinations should be required for qualification candidates. However, they are not required when the training curriculum does not support the need for written examinations, or when the administration of a written examination does not add value to the overall qualification process.

Operational Evaluations

Operational evaluations should be required for qualification candidates.

Maintenance of Proficiency

Initial qualifications should be issued for an effective period not to exceed two (2) years, unless otherwise suspended or revoked, at which time Requalification is required. If it is determined at any time that the capabilities of an individual are not in accordance with the qualifications specified for that job, that individual should be removed from that job. Reinstatement may be made upon completion of remedial actions, such as retraining and/or reexamination.

Requalification Factors

The qualification procedure should clearly denote which method of Requalification is required for the specified job function. Requalification should be granted based upon successful completion of Requalification examinations (written and/or operational evaluation) or continuous satisfactory performance documented in writing by the cognizant supervisor and approved by the applicable line manager.

Other Qualified Positions

The qualification program for positions other than operators and supervisors should be detailed in a procedure that addresses education and experience, medical examination criteria, and training and examination requirements, as appropriate to the job function. Upon completion of program requirements, the candidate may be granted qualification. Personnel qualifications other than those for operators and supervisors may be issued with an indefinite effective period, unless otherwise suspended or revoked, at which time Requalification is required.

Certification Requirements

Certified Operators and Supervisors

The program leading to certification for operators and supervisors should be governed by a written procedure, which includes requirements for documented assessment of the person's qualifications through examination and operational evaluations. Upon completion of program requirements, the candidate may be granted certification. The procedure should address the following elements:

Education and Experience

Minimum education and experience requirements should be established. Recommended requirements are detailed in Appendix D.

Specific Training

Specific training programs should be established to develop or enhance the knowledge, skills, and ability of certified operators and certified supervisors to perform job assignments. The program should consist of a combination of classroom and on-the-job training, as it applies to the position and include training on basic theory and fundamentals, principles of facility operation and operating characteristics, facility systems, and normal, abnormal, and emergency operating procedures. The training curriculum should prescribes the minimum training required for certification, and include classroom, practical and on-shift training.

Medical Examinations

A candidate for certification should received an initial medical examination by a physician and should be reexamined at least every 2 years to verify health and physical fitness to perform assigned tasks safely. Medical examination criteria and documentation should be detailed in the certification procedure.

Written Examinations

Written examinations should be required for certification candidates.

Oral Examinations

Oral examinations should be required for certification candidates if the position requires the ability to work proficiently under pressure and to make facility-affecting decisions in real-time scenarios. Oral examinations may be conducted as a one-on-one walkthrough or as a formal oral board.

Operational Evaluations

Operational evaluations should be required for certification candidates.

Independent Verification

The qualifications of candidates should be independently verified prior to certification. This verification should be performed by an individual who was not involved in the training process or who is not in the candidate's line organization. The Independent Verification process should be described in the certification procedure.

Maintenance of Proficiency

Initial certifications are issued for an effective period not to exceed two (2) years, unless otherwise suspended or revoked, at which time recertification is required. Certified operators and supervisors should actively participate in certification duties to maintain an active certification status. The certification procedure should establish requirements and frequency necessary to maintain an active status. Evidence of this activity must be documented and retained in the individual's file. If an individual has not performed within this specified time, the certification should be suspended and placed on "inactive" status. If it is determined at any time that the capabilities of an individual are not in accordance with the qualifications specified for that job, that individual should be removed from that job. Reinstatement may be made upon completion of remedial actions, such as retraining and/or reexamination.

Recertification and Certification Extension

The certification procedure should denote which method of recertification is required for the specified job function. Recertification of operators and supervisors is based upon: continuous active status in the certification; has performed certification duties competently and safely; has a current medical examination; capable of continuing to assume certification duties competently and safely; current in the continuing training program; and comprehensive evaluation of performance is documented in writing and approved by the applicable line manager.

Certifications may be extended for ninety (90) days beyond the effective period of certification with written approval of the certifying authority. In no case should a certification be extended beyond 180 days.

Other Certified Positions

The certification program for other certified positions should be detailed in a procedure that addresses education and experience, medical examination criteria, and training and examination requirements, as appropriate to the job function. Upon completion of program requirements, the candidate may be granted certification. Other personnel certifications are issued with an effective period specified by a national consensus code or standard, as appropriate, unless otherwise suspended or revoked, at which time recertification is required.

Examinations

Procedures for development, approval, security, administration, and maintenance of examinations and operational evaluations should be established.

Written Examinations

Written examinations should be based upon the topics presented in classroom training portion of the training curriculum as detailed in the qualification or certification procedure and contain a representative selection of questions derived from these topics. The qualification or certification procedure should identify the passing score for written examination. The written examination score for qualification or certification may be a composite grade of all individual examination scores.

Oral Examinations

Oral examinations should be based upon the topics presented in classroom and/or practical training portion of the training curriculum detailed in the certification procedure. No numerical value is assigned to oral examinations. The candidate's responses should be evaluated by the examiner as “satisfactory” or “unsatisfactory” based upon the individual exhibiting a basic knowledge in the questioned area and the individual is capable of correctly responding to the question. The questions asked, the candidate's responses to those questions, and the examiner's evaluation should be documented. The oral examination score for certification should be a composite grade of all individual oral examinations.

Operational Evaluations

Operational evaluations are based upon the performance items presented in practical training portion of the training curriculum detailed in the qualification or certification procedure. Operational evaluations should require the candidate to demonstrate an understanding of, and the ability to perform the actions necessary to operate the facility safely. Operational evaluations should contain questions and operational exercises, and may include system and/or component operations. No numerical value is assigned to operational evaluations. The candidate's demonstrations are evaluated by the examiner as “satisfactory” or “unsatisfactory.” The job functions demonstrated, the candidate's performance in these demonstrations, and the examiner's evaluation should be documented. The operational evaluation score for qualification or certification should be a composite grade of all individual operational evaluations.

Records

Each qualification and certification procedure should specify the records used to document an individual’s qualifications, and specify how such documentation is processed for approval. Training records should be developed, prepared, and maintained in accordance with written procedures. These procedures should identify the types of records kept and organization responsible for controlling and retaining training records.

Records of initial qualification, certification and Requalification should be maintained as individual files. Records should be documented and include the following types of information:

1. Records of education and experience, including resumes;

2. Results of medical examinations (when required);

3. Records of training completed, such as attendance sheets or computer summaries;

4. Records of training exceptions;
5. Results of examinations, including written examinations and operational evaluations (when required);
6. Evidence of maintenance of proficiency; and
7. Approvals and effective dates, if applicable.

APPENDIX A

CONDUCT OF OPERATIONS SUPPLEMENTAL GUIDANCE

DOE-STD-1030-96	Guide to Good Practices for Lockouts and Tagouts
DOE-STD-1031-92	Guide to Good Practices for Communications *(includes Change Notice No. 1, December 1998)*
DOE-STD-1032-92	Guide to Good Practices for Operations Organization and Administration *(includes Change Notice No. 1, December 1998)*
DOE-STD-1033-92	Guide to Good Practices for Operations and Administration Updates through Required Reading *(includes Change Notice No. 1, December 1998)*
DOE-STD-1034-93	Guide to Good Practices for Timely Orders to Operators *(includes Change Notice No. 1, December 1998)*
DOE-STD-1035-93	Guide to Good Practices for Logkeeping *(includes Change Notice No. 1, December 1998)*
DOE-STD-1036-93	Guide to Good Practices for Independent Verification *(includes Change Notice No. 1, December 1998)*
DOE-STD-1037-93	Guide to Good Practices for Operations Aspects of Unique Processes *(includes Change Notice No. 1, December 1998)*
DOE-STD-1038-93	Guide to Good Practices for Operations Turnover *(includes Change Notice No. 1, December 1998)*
DOE-STD-1039-93	Guide to Good Practices for Control of Equipment and System Status *(includes Change Notice No. 1, December 1998)*
DOE-STD-1040-93	Guide to Good Practices for Control of On-shift Training *(includes Change Notice No. 1, December 1998)*
DOE-STD-1041-93	Guide to Good Practices for Shift Routines and Operating Practices *(includes Change Notice No. 1, December 1998)*
DOE-STD-1042-93	Guide to Good Practices for Control Area Activities *(includes Change Notice No. 1, December 1998)*
DOE-STD-1043-93	Guide to Good Practices for Operator Aid Postings *(includes Change Notice No. 1, December 1998)*
DOE-STD-1044-93	Guide to Good Practices for Equipment and Piping Labeling *(includes Change Notice No. 1, December 1998)*
DOE-STD-1045-93	Guide to Good Practices for Notifications and Investigation of Abnormal Events *(includes Change Notice No. 1, December 1998)*
DOE-STD-1050-93	Guideline to Good Practices for Planning, Scheduling and Coordination of Maintenance at DOE Nuclear Facilities

APPENDIX B

EMERGENCY PREPAREDNESS SUPPLEMENTAL GUIDANCE

DOE 5500.1A	Emergency Management System
DOE 5500.2	Emergency Planning, Preparedness and Response for Operations
DOE 5500.2A	Emergency Notification, Reporting and Response Levels
DOE 5500.3A	Emergency Planning and Preparedness for Operational Emergencies
DOE 5500.4A	Public Affairs Planning Requirements for Emergencies
DOE 5500.8	Emergency Planning and Management
ANS 15.16	Emergency Planning for Research Reactors
NFPA 1561	Standard on Fire Department Incident Management System

APPENDIX C

EMERGENCY PREPAREDNESS DEFINITIONS

Affected Persons	Individuals who have been exposed or physically injured as a result of an accident to a degree requiring special attention, e.g., decontamination, first aid, or medical services.
Assessment Actions	Those actions taken prior to, during or after an accident which are collectively necessary to make decisions to implement specific emergency measures.
Corrective Actions	Those emergency measures taken to ameliorate or terminate an emergency situation at or near the source of the problem.
Emergency Action Levels	Radiological dose rates; specific contamination levels of airborne, water-borne, or surface-deposited concentrations of radioactivity; or specific instrument readings that may be used as thresholds for initiating specific emergency measures.
Facility	Equipment, structure, system, process, or activity that fulfills a specific purpose. Examples include accelerators, storage areas, fusion research devices, and research laboratories.
Operational Emergencies	Are those radiological and non-radiological accidents and events associated with the serious degradation of safety or security at a DOE owned or leased Research & Development facility, operation, or activity.
Protective Actions	Those emergency measures taken after an uncontrolled release of radioactive material has occurred for the purpose of preventing or minimizing radiological exposures to persons that would be likely to occur if the actions were not taken.
Population at Risk	Those persons for whom protective actions are or would be taken.
Recovery Actions	Those actions taken after the emergency to restore the plant as nearly as possible to its pre-emergency condition.

APPENDIX D

TRAINING AND QUALIFICATION REQUIREMENTS

TERMS AND DEFINITIONS

Certificate of Qualification - document signed by the certifying authority attesting to an individual's certification.

Certification - process by which management provides written endorsement of the satisfactory achievement of qualification of an individual for a specialized operations position based upon its criticality or safety impact, and generally in response to a DOE Order or national consensus code or standard.

Certifying Authority - that individual who certifies operators and operator supervisors, in accordance with a certification procedure.

Maintenance Personnel - persons responsible for performing maintenance and repair of mechanical and electrical equipment.

Managers - persons whose assigned responsibilities include ensuring that a facility is safely and reliably operated, and that supporting operating and administrative activities are properly controlled. Each facility should determine which level personnel and higher are considered Managers.

On-Shift Training - that portion of qualification training where the student receives training within the job environment and with as much hands-on experience as possible.

Operators - persons responsible for manipulating facility controls, monitoring facility parameters, and operating facility equipment.

Certified Operators - operators who require certification as determined by facility management.

Qualified Operators - operators who require qualification as determined by facility management.

Qualification - process by which factors, such as education, experience, and any special requirements (e.g., medical examination) are evaluated in addition to training to assure that an individual can competently perform a specialized job function to an anticipated level of proficiency.

Qualified - the ability to perform a specific job function based upon completion of a training, qualification, or certification program developed for the job function. Trained personnel are qualified to perform their job function based upon completion of training. Qualified and certified personnel are qualified to perform their job function based upon completion of a specific program. As used in this document, the term "qualified" personnel has two meanings, based upon context:

Qualified personnel are those personnel who have successfully completed either training, qualification, or certification requirements appropriate to their job function.

Qualified personnel are those personnel who have successfully completed a formal qualification program appropriate to their job function.

Statement of Qualification - document signed by an appropriate individual (supervisory or higher) indicating that an individual is qualified to perform a specialized job function to an anticipated level of proficiency.

Supervisors - persons who are responsible for the quantity and quality of work, and who direct the actions of the operators or other personnel.

Certified Supervisors - supervisors who are responsible for the operational activities of certified operators who require certification as determined by facility management.

Qualified Supervisors - supervisors who are responsible for the operational activities of qualified operators who require qualification as determined by facility management.

Technicians - persons responsible for performing specific maintenance or analytical laboratory work.

Operations and Facility Support Personnel - those individuals who perform technical functions, (such as engineering evaluations, program reviews, technical problem resolution, or data analyses, within their area of expertise), or safety, quality assurance, radiation protection, emergency services, and training functions.

Training Matrix - A listing of the courses and other appropriate requirements to be completed by an individual in order to satisfy training requirements for a specified job function. Training requirements and recommendations are matrixed by position.

GUIDANCE DOCUMENTS

10 CFR 830	Nuclear Safety Management
29 CFR 1910	OSHA Regulations
29 CFR 1926	OSHA Construction Regulations
DOE Order 4330.4A	Maintenance Management Program *(canceled, replaced by DOE Order 4330.4B)*
DOE Order 5480.20A	Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities
DOE Order 5480.9A	Construction Project Safety and Health Management
DOE-HDBK-1001-96	Guide to Good Practices For Training and Qualification of Instructors
DOE-HDBK-1002-96	Guide to Good Practices for Training and Qualification of Chemical Operators
DOE-HDBK-1003-96	Guide to Good Practices for Training and Qualification of Maintenance Personnel
DOE-HDBK-1074-95	Alternative Systematic Approaches to Training
DOE-HDBK-1080-97	Guide to Good Practices For Oral Examinations
DOE-HDBK-1114-98	Guide to Good Practices For Line and Training Manager Activities
DOE-HDBK-1116-98	Guide to Good Practices for Developing and Conducting Case Studies
DOE-HDBK-1200-97	Guide to Good Practices For Developing Learning Objectives
DOE-HDBK-1201-97	Guide to Good Practices Evaluation Instrument Examples
DOE-HDBK-1202-97	Guide to Good Practices For Teamwork Training and Diagnostic Skills Development
DOE-HDBK-1203-97	Guide to Good Practices For Training of Technical Staff and Managers
DOE-HDBK-1204-97	Guide to Good Practices For the Development of Test Items
DOE-HDBK-1205-97	Guide to Good Practices for the Design, Development, and Implementation of Examinations
DOE-HDBK-1206-98	Guide to Good Practices For On-the-Job Training
DOE-STD-1029-92	Writer's Guide for Technical Procedures *(includes Change Notice No. 1, December 1998)*
DOE-STD-1059-93	Guide to Good Practices for Maintenance Supervisor Selection and Development

DOE-STD-1060-93	Guide to Good Practices For Continuing Training
DOE-STD-1061-93	Guide to Good Practices For the Selection, Training , and Qualification of Shift Supervisors
DOE/EH-0256T Rev 1	DOE Radiological Control Manual
DOE/EH-0353P	Occupational Safety and Health Technical Reference Manual
DOE/NE-0102T	TAP 2 - Performance-Based Training Manual
DOE/NE-0103T	TAP 3 - Training Program Support Manual
SG 830.120	Safety Guide for Quality Assurance
SG 830.310	Guidelines for the Conduct of Operations at DOE Facilities
SG 830.330	Guidelines for the Selection, Training, Qualification and Certification of Personnel at DOE Nuclear Facilities
TTR89-009	TRADE Document TTR89-009,"Job Task Analysis - Guide to Good Practices: Volumes I & II"
TTR92-010	TRADE Document TTR92-010, "The Occasional Trainer's Handbook," 1992

EDUCATION AND EXPERIENCE

Minimums

Position	Education	Experience
Operators	High School	2 Years
Technicians	High School	1 Year
Maintenance Personnel	High School	1 Year
Supervisors	High School	3 Years
Operations and Facility Support Functions (Note 1)	Baccalaureate in Engineering or Related Science	2 Years
Operations and Facility Support Functions (Note 2)	High School	Work experience as appropriate to the specific job-function
Managers	Baccalaureate in Engineering or Related Science	4 Years
Training Manager	Baccalaureate with course work in education and technical subjects	4 Years

Note 1 Operations and Facility Support personnel who perform engineering or analytical support functions.

Note 2 Operations and Facility Support personnel who perform specialized support functions (such as quality control, radiation control, or emergency response).

Alternatives Guidelines

The education and experience guidelines written below may be considered when making an evaluation of alternatives, recognizing that other factors (such as job incumbency and the ability to competently perform the assigned job function) and may also be appropriate in lieu of the education and experience minimums specified.

Education Alternatives

The education requirements identified in this section are high school diploma and baccalaureate degree. Persons who do not possess the formal educational requirements specified should not be automatically eliminated where other factors provide sufficient assurance of their abilities to fulfill the duties of a specific position. These factors should be evaluated on a case-by-case basis, and approved and documented.

High School Alternatives:

General Educational Development (GED) diploma or completed test.

Certificate of Completion from a post-secondary technical institution.

Completion of technical training provided by the US Armed Forces.

College Alternatives:

Professional engineer license.

Completion of technical portions of a baccalaureate program, with the overall completion of 80 semester credit hours, as determined by a written transcript.

Related experience substituted for education at the rate of six semester credit hours for each year of experience up to a maximum of 80 credits.

Experience Alternatives

Persons who do not possess the experience requirements specified should not be automatically eliminated where other factors provide sufficient assurance of their abilities to fulfill the duties of a specific position. These factors should be evaluated on a case-by-case basis, and approved and documented in accordance with this procedure.

General:

In those cases where an individual does not meet the literal experience required for a position, <u>and no other basis for an experience alternative is available</u>, consideration may be given to the collective experience of the operating organization in lieu of the individual meeting the required experience. Individuals may be assigned to positions providing the overall operating organization is considered balanced and strong. In such cases, management approval of this approach (documented in a memorandum) is required.

Substitution of Course Work and Training:

Where course work is related to job assignments, post-secondary education may be substituted. Formal education may not be substituted for more than 50% of the experience requirements unless otherwise specified herein.

Job-related training in the position sought may qualify as equivalent to nuclear experience on a one-to-one basis for up to a maximum of two years.

Completion of technical training provided by the United States Armed Forces.

Training And Qualification Requirements - Basis and Rationale

The Training and Qualification section of the Fusion Safety Standard is based upon the referenced documents shown in Appendix 1. The program is a compilation of expected requirements [10CFR830] as well as existing programs in place due to DOE orders. It also includes information from other standards and documents. If a facility develops a comprehensive program for training and qualification of its staff using this document on a graded approach, the intent of the requirements and reference documents will be achieved. The overall effectiveness of such a program can only be determined by evaluating the effectiveness of the facility during operations.