Division 8
Doors and Windows

0800 GENERAL

See Section 0110-12, Energy Conservation, for coefficients of heat transmission, shading of glass, double and triple glazing, air infiltration and exfiltration, thermal break frames and framing members, weatherstripping, and vestibules and protected entrances for exterior doors.

Doors and windows located in potentially corrosive environments, such as in close proximity to saltwater or in areas of acid rain, shall be corrosion resistant or protected against corrosion.

See Section 0101-4, Handicapped Provisions.

0800-1 DOORS

0800-1.1 General

Frequently used doors shall have a vision panel except where privacy, security, or fire safety requirements preclude installation.

Doors shall offer substantial resistance to unauthorized entry but need not be more resistant to penetration than adjoining walls, ceiling, and floors. If visual access is not a factor, doors with glass panels may be used; however, they shall comply with Section 0800-2, Windows, or shall be equipped with wire mesh fastened securely to the door, preferably on the inside. When visual access is a factor, a sight baffle shall be used when a door is open and should also block the view of the area when the door is closed. When doors are used in pairs, an overlap molding is required where the doors meet. Door jambs shall be reinforced when necessary to make it more difficult to open by use of a wedge, jimmy, or similar tool.

0800-1.2 Fire Protection

Fire doors, frames, and hardware shall be either tested and listed by UL or similar nationally accredited testing laboratories or approved by FM or similar national insurance organizations. Fire doors, frames, and hardware shall be installed with label attached in accordance with NFPA 80.

0800-1.3 Security

Where more than one door is required for a security area, single doors or double doors with a removable mullion between them shall be used.

Doors that seine exclusively as exits from security area shall not be operable from outside the security area.

Where primary reliance is placed on doors as physical security barriers, they shall provide a penetration resistance equal to that specified in the site-specific security plan for adjoining walls, ceilings, and floors.

Doors that serve as exits from security areas shall comply with NFPA 101, Chapter 5, and with DOE security requirements, except the use of panic hardware on doors from security areas shall be limited to assembly, educational, and hazardous occupancy classifications of UBC as determined by the cognizant DOE authority.

Openings in doors shall be covered to provide the necessary barrier delay rating required by the site-specific security plan for that door. Various materials and configurations may be used, if they are approved by the cognizant DOE safeguards and security authority.

Doors that seine as emergency exits from spaces should not open into spaces of greater security.

Where used to enhance penetration resistance, wire mesh shall be 2-inch square or smaller mesh of No. 11 American Wire Gauge or heavier steel wire or expanded metal.

Doors of offices or rooms constituting security area perimeters where Secret or Top Secret information is discussed on a recurring or routine basis shall be constructed of materials of low sound conductivity, or shall otherwise be soundproof in accordance with DOE 5636.3A and the DOE TSCM Procedural Guide so as to prevent a person outside the room with reasonable access to the wall from overhearing a conversation at normal voice level within the room without the use of hearing instruments or equipment.

Access doors to security posts shall be provided with positive locking devices to prevent unauthorized entry.

0800-2 WINDOWS

0800-2.1 General

All facilities shall have operable windows for ventilation except those facilities with year-round air-conditioning such as some computer rooms, where windows shall not be operable except for window cleaning purposes.

Operable windows used for ventilation shall have insect screens.

Where double or triple glazing is required, insulating glass units shall be used, not multiple glazing.

Windows and curtain walls shall be designed for wind loads in accordance with UBC.

Windows shall offer substantial resistance to unauthorized entry but need not be more resistant to penetration than adjoining walls, ceilings, and floors.

0800-2.2 Fire Protection

Where required by code, fire windows, frames, and hardware shall be either tested and listed by UL or similar nationally accredited testing laboratories or approved by FM or similar national insurance organizations. Such fire windows, frames, and hardware shall be installed with label attached in accordance with NFPA 80.

0800-2.3 Safety

Operable outside windows and operable windows at air shafts, atriums, and courtyards shall have guards conforming to NFPA 101, Chapter 5.

Window cleaning provisions shall comply with ANSI A39.1.

Outside windows and glazed curtain walls shall comply with NFPA 101, Chapter 22, and shall have clear openings that qualify as second means of escape.

0800-2.4 Maintenance and Repair

Operating mechanisms, parts, and equipment in operable windows shall have a history of reliability and readily available replacement parts, and shall not be made of zinc.

0800-2.5 Screens

Where insect screens are used, they shall not require seasonal removal and storage, and they shall not interfere with normal window operations.

Screen frames of aluminum may be used with wood, aluminum, or steel windows. Screen frames of wood shall be used only with wood windows. Screen frames of steel shall be used only with wood or steel windows. Screen frames of bronze shall be used only with bronze windows.

Aluminum and plastic coated or impregnated fibrous glass insect screen shall be used with wood, aluminum, bronze, or steel screen frames. Aluminum insect screen shall not be used where it is exposed to a saltwater atmosphere. Bronze insect screen shall be used only with wood, bronze, or steel screen frames. Glass fabric insect screening shall comply with ASTM D3656.

0800-2.6 Security

Where primary reliance is placed on windows as physical security barriers, they shall provide a penetration resistance equal to that specified in the site-specific security plan for adjoining walls, ceilings, and floors.

Where primary reliance is placed on windows as physical barriers, they shall be constructed of shatter-resistant, laminated glass panes of 9/32-inch minimum thickness or other material providing an equal degree of resistance, and installed in fried (e.g., unopenable) frames so that the panes are not removable from outside the area being protected. The frames must be securely anchored in the walls, and windows should lock from the inside. Swingout steel sash (industrial-type) is acceptable for window installation provided the windows can be securely locked or are permanently sealed shut.

Where used to increase penetration resistance, wire mesh shall be 2-inch square or smaller mesh of No. 11 AWG or heavier steel wire or expanded metal.

0810 METAL DOORS AND FRAMES

0810-1 STEEL DOORS AND FRAMES

Hollow steel doors and frames shall comply with SDI 100 and SDI 108.

Insulated steel door systems shall comply with ISDSI 102.

Steel exterior doors shall not be used in saltwater environments.

0810-2 ALUMINUM DOORS AND FRAMES

Aluminum sliding glass doors shall comply with AAMA 101.

Insulating aluminum products for sliding glass doors shall comply with AAMA 1002.10.

Aluminum sliding screen doors shall comply with SMA 2005.

Aluminum swinging screen doors shall comply with SMA 3001.

Aluminum storm doors shall comply with AAMA 1102.7.

Aluminum exterior doors shall not be used in saltwater environments.

0820 WOOD AND PLASTIC DOORS

0820-1 WOOD DOORS

Exterior doors and interior doors where significant moisture is normally present (such as shower rooms, drying rooms, and dishwashing rooms) shall not be faced with hardboard or have unimpregnated paper honeycomb door cores or paper honeycomb door cores with foam plastic fill or vermiculite fill.

Wood doors shall comply either with NWWDA IS-1 and NWWDA IS-3, and NWWDA IS-6.

Wood exterior doors and plastic-faced exterior doors shall be protected from direct exposure to weather.

0830 SPECIAL DOORS

Single-leaf double-acting doors shall have vision panels.

Single-leaf double-acting doors shall not be used except as interior personnel passage doors between work spaces that have no security requirements, that have relatively few people, and that do not receive, store, or transfer hazardous, critical, or fragile material or equipment.

Where a single-leaf double-acting door is functionally needed but otherwise unacceptable, one of the following shall be used:

- A pair of manually or automatically operated single-acting doors, with each door swinging in a different direction
- An automatic single horizontal sliding door or pair of horizontal sliding doors

Pairs of double-acting doors shall have a vision panel in each leaf.

Pairs of double-acting doors shall not be used except as interior passage doors between industrial type areas that have no security requirements, that have relatively few people and little cross traffic, and that do not receive, store, or transfer hazardous, critical, or fragile material or equipment.

Where a pair of double-acting doors is functionally needed but otherwise unacceptable, one of the following shall be used:

- Two pairs of single-acting doors, with each pair swinging in a different direction
- A pair of automatic horizontal sliding doors
- An automatic overhead coiling door

0833 COILING DOORS

Exterior overhead rolling metal curtain doors shall be fully weatherstripped.

0836 SECTION OVERHEAD DOORS

Sectional overhead doors shall comply with ANSI A216.1.

0839 SCREEN AND STORM DOORS

Storm doors shall not be used at exterior exits from boiler rooms, mechanical and electrical equipment rooms, storage rooms, and similar normally unoccupied rooms.

Aluminum and plastic coated or impregnated fibrous glass insect screen shall be used with wood, aluminum, or steel screen frames. Aluminum insect screen shall not be used where it is exposed to a saltwater atmosphere. Bronze insect screen shall be used only with wood, bronze, or steel screen frames. Glass fabric insect screening shall comply with ASTM D3656.

0850 METAL WINDOWS

0850-1 STEEL WINDOWS

All steal insect screen frames shall be hot dipped galvanized sheet steel with a durable baked enamel finish.

Steel windows shall comply with SWI Specifications Brochure for Steel Windows.

0850-2 ALUMINUM WINDOWS

Aluminum windows shall comply with AAMA 101.

Aluminum storm products for windows and sliding glass doors shall comply with AAMA 1002.10.

0860 WOOD AND PLASTIC WINDOWS

0860-1 WOOD WINDOWS

Wood windows shall comply with NWWDA IS-2 and NWWDA IS-7.

0870 HARDWARE

Door and window hardware shall comply with the ANSI A156 series.

The preparation of doors and frames for the installation of bolts, closers, latches, locks, pivots, and strikes shall comply with the ANSI A115 series.

Keying systems for new and renovated facilities and new additions shall be coordinated with existing facilities on a site.

Doors that are part of a fire-rated wall assembly and exterior swinging doors that open out shall have door closers.

Zinc hardware shall not be used.

Operable windows located more than 6 feet above the finished floor shall be provided with extension operators or poles.

The locks on at least one door of any room shall be equipped to prevent personnel from being locked inside, except as otherwise required to satisfy DOE safeguards and security standards.

Door silencers shall be used on all metal door frames except those for double-acting doors and those for doors in rooms with acoustical security.

Where primary reliance is placed on doors or windows as physical security barriers, heavy-duty builders' hardware shall be used, and all screws, nuts, bolts, hasps, clamps, bars, wire mesh, hinges, and hinge pins shall be fastened securely to preclude surreptitious removal and assure visual evidence of tampering. Hardware accessible from outside the area shall be peened, brazed, or spot welded to preclude removal or be otherwise secured by hardware that is inaccessible to unauthorized tampering (e.g., nonrenewable hinge pins).

Where primary reliance is placed on doors as physical security barriers, locks shall meet the following requirements:

- A combination lock shall meet UL 768, Group I-R.
- A combination padlock shall meet FS FF-P-110 and 41 CFR 101.
- A key padlock shall meet MIL-P-43951 or FS FF-P-001480.
- A key lockset shall meet the ANSI A156 series.
- Panic locks used on emergency exit doors in security area perimeters shall be operable only from the inside and shall be equipped with at least a loud local alarm. Door locks and latches shall comply with NFPA 101.
- Magnetic-type locks shall have at least 1200-pound holding force.

- Locks not covered by the above requirements and that meet protection objectives may be used with DOE field element approval.

0880 GLAZING

Glazing materials with reflective matings or films shall not be used where they cause disorientation and unsafe conditions.

Glazing materials adjacent to unattended entrances and exits shall be protected from damage.

Glazing methods and materials shall comply with FGMA Glazing Manual and FGMA Sealant Manual.

Flat glass shall comply with ASTM C1036.

For protective glazing, see Section 0800-2.6, Security.

Division 9
Finishes

0900 GENERAL

0900-1 GENERAL

The underside of floor and roof construction shall be exposed to view except where acoustical treatment, heating, ventilating, air-conditioning, cleanliness, or the containment or dispersion of contaminants requires the installation of a ceiling.

In the planning and design of new facilities, economy in finishes shall be considered in terms of the following factors:

- The character of the facility
- Functional requirements
- LCC

0900-2 FIRE PROTECTION

LCC calculations shall include the renewal of fire retardant coatings as required by NFPA 101, Chapter 31.

0900-3 HAZARDOUS MATERIALS CONTAMINATION

Where radioactive or other hazardous materials are processed or handled, and contamination can occur, washable or strippable finishes shall be used on walls, floors, and ceilings.

Where radiological contamination can occur, paint finishes shall comply with ANSI N512.

0900-4 INDOOR AIR QUALITY

Finish material and its support, backup, and substrate shall be selected, designed, fabricated, assembled, and installed to exclude or prevent the escape of fibers, such as asbestos, and the escape of emissions from volatile organic compounds, such as formaldehyde, and combinations of volatile organic compounds that have been determined to be a health hazard.

0900-99 SPECIAL FACILITIES

0900-99.0 Nonreactor Nuclear Facilites-General

Rounded corners and epoxy coated concrete walls and floors shall be considered for nuclear materials storage and work areas.

In addition to the coating requirements provided in Section 0950, Acoustical Treatment, the design professinal shall consider the coating guidelines in ASTM D4256 and ANSI N512 for facilities that require coatings to enhance decontamination of surfaces or because of environmental conditions.

090049.4 Exlosives Facilities

0900-99.4.1 Radiological Design Requirements

These design requirements are to be applied specifically where explosives and plutonium are present in the same bay (except magazines) and shall be in addition to requirements and practices associated with the use of other radioactive materials such as uranium and tritium.

Ease of radiological decontamination shall be provided for in the selection of floor and wall coverings. Where paints are to be used, they shall comply with ANSI N512. To the extent practicable, floor-to-wall interfaces shall be coved for ease of decontamination

0900-99.7 Occupational Health Facilities

0900-99.7.1 General

The functional shall dictate the selection of interior finishes for Occupational Health Facilities. Particular care shall be taken to assure the privacy of conversations between doctor or medical professional and patient.

See Section 1300-11.1, Decontamination, for interior finish criteria applicable to contaminated areas in Occupational Health Facilities.

0900-99.7.2 Floors

Finished floors shall be resilient flooring except in special areas. In such areas such as laboratories and dark rooms, vinyl composition and rubber or vinyl cove base shall be used.

Emergency rooms or surgical areas shall have vinyl, all-purpose, static-proof, conductive flooring.

Stairways, entries, and service and utility areas shall generally be concrete (concrete cove base in janitor's closet).

Corridor flooring may be concrete or resilient flooring with rubber or vinyl cove base. Toilet and washrooms shall have ceramic tile floor and base.

0900-99.7.3 Walls

The use of plaster shall generally be avoided except as required in potentially contaminated areas to facilitate decontamination and in such areas as emergency, X-ray, treatment, or dark rooms. Painted finishes shall be used throughout the remainder of the facility, such as on masonry walls, dry wall, and factory finished panels. Stairways and corridors may be protected with hardboard wainscot. Portland cement plaster or tile may be used for wainscots in built-in shower stalls.

Where tile is to be used, structural facing units shall be considered. Proper radiation shielding shall be provided for X-ray and control rooms. The services of persons qualified in radiation shielding, particularly as related to X-ray shieldins, shall be used for design.

0900-99.7.4 Ceilings

The use of plaster for ceilings shall be limited to those rooms where it is used as a wall finish. Acoustical treatment shall be used where functionally needed. Acoustical materials shall be noncombustible and shall be applied directly to the ceiling unless other methods of installation are more economical, or where suspended ceiling is justified for sanitary or other reasons.

090049.7.5 Doors and Frames

Wood or combination steel buck and frame shall be used with wood flush doors. The use of sliding doors in medical units should be avoided because of difficulty in maintaining cleanliness. Doors shall be sized to allow passage of stretchers, where needed.

0910 METAL SUPPORT SYSTEMS

0910-1 NON-LOAD BEARING WALL FRAMING SYSTEMS

Steel framing shall comply with the MLSFA Steel Flaming Systems Manual and UBC Chapter 23. See Section 0111, Structural Design Requirements.

0910-2 CEILING SUSPENSION SYSTEMS

Suspended ceilings shall be earthquake resistant. They shall comply with:

- UBC Standard No. 47-18
- ICBO Report 4071

- ASTM C635
- ASTM C636
- ASTM E580

Nonstructural suspended systems, including ceilings, electrical components, and equipment, shall be considered in terms of UCRL 15714, Section V.

0920 LATH AND PLASTER

0920-1 VENEER PLASTER

Veneer plaster shall comply with GA Manual of Gypsum Veneer Plaster.

0925 GYPSUM BOARD

The application and finishing of gypsum shall comply with ASTM C840. See Section 0111, Structural Design Requirements.

0930 TILE

0930-1 CERAMIC TILE

Ceramic tile shall comply with TCA Handbook for Ceramic Tile Installation.

0950 ACOUSTICAL TREATMENT

0950-1 GENERAL

Acoustical analyses shall be made for areas with high sound levels, areas where speech intelligibility is important to occupant performance, and for areas where speech privacy is important to occupant performance or required for security. These areas include but are not limited to industrial facilities, data processing centers, word processing centers, large conference rooms, auditoriums, audio-video studios, program control centers, open offices, and secure rooms.

A continuous IAS shall be provided for occupiable spaces above suspended ceilings within protected areas and, as required by the site-specific security plan, within limited and exclusion areas.

Acoustical treatments in industrial facilities and other high noise occupancies shall comply with 29 CFR 1926 and 29 CFR 1910.

Facilities with low sound levels shall be provided with acoustical treatments that produce balanced acoustical environments and promote occupant productivity.

No acoustical treatment shall be provided to control the acoustical environment within normally unoccupied storage areas, service areas, or support areas that have lower sound levels.

Acoustical treatment and administrative control in areas that require periodic occupancy by operations or maintenance personnel (for example, utility rooms, equipment rooms, storage areas, service areas, support areas, and industrial process areas) and have such high sound levels that personnel would be injured by periodic short-duration exposure shall comply with 29 CFR 1926 and 29 CFR 1910.

Acoustical material shall not be in contact with the underside of roof decks where moisture can collect, or where the deck is exposed to extreme heat.

Where window treatments and office landscaping are used for acoustical treatments, see Section 1250, Window Treatment, and Section 1260-1, Landscape Partitions and Components.

Accoustical ceilings shall comply with CISCA Acoustical Ceiling-Use and Practice.

Acoustic plaster ceilings shall not be used.

In areas subject to moisture or high humidity, such as shower rooms, kitchens, and spaces with industrial processes using water, any metal suspension system shall be corrosion resistant, and ceiling materials shall be protected from moisture or be moisture resistant.

0950-99 SPECIAL FACILITIES

0950-99.10 Secure Conference Rooms

Walls, ceiling, and doors of offices or room constituting security area perimeters where classified information is discussed, handled, or processed on a recurring or routine basis shall be constructed of materials of low sound conductivity, and shall be acoustically treated in accordance with DOE 5636.3A and the DOE TSCM Procedural Guide so as to prevent a person outside the room with reasonable access to the wall from overhearing a conversation at normal level within the room without the use of hearing instruments or equipment. (See Section 0110-99.10, Secure Conference Rooms, for additional requirements for soundproofing of secure conference rooms.)

0950-99.11 Secure Offices

Walls, ceilings, and doors of offices or rooms constituting security area perimeters where classified information is discussed, handled, or processed on a recurring or routine basis shall be constructed of materials of low sound conductivity, or shall otherwise be acoustically treated in accordance with DOE 5636.3A and DOE TSCM Procedural Guide, so as to prevent a person outside the room with reasonable access to the wall from overhearing a conversation at normal level within the room without the use of hearing instruments or equipment. (See Section 0110-99.11, secure Offices, for additional requirements for soundproofing of secure offices.)

0965 RESILIENT FLOORING

Resilient flooring installation shall comply with the RFCI Recommended Work Procedures for Resilient Floor Covering.

Where seamless sheet flooring is required, seams shall be sealed in accordance with ASTM F693.

Electrically conductive floors shall comply with UL 779.

0968 Carpet

Carpet shall comply with CRI Garpet Specifiers Handbook and CRI Standard for Installation of Textile Floor Covering Materials.

Flame spread shall not be greater than 75 when tested in accordance with ASTM E84. For computer facilities, flame spread shall not be greater than 25 per DOE/EP 0108.

Flame propagation index shall be less than 4.0 when tested in accordance with UL 992, or the minimum average critical radiant flux shall be 0.45 watt per square centimeter when tested in accordance with ASTM E648.

0970 SPECIAL FLOORING

0970-1 RESINOUS FLOORING

Industrial resinous flooring (seamless coating) and conductive spark-proof industrial resinous flooring shall comply with NTMA requirements.

0970-2 CONDUCTIVE FLOORING

Conductive flooring shall comply with Section 1660-99.4.3, Static Electricity.

0970-99 SPECIAL FACILITIES

0970-99.4 Exlosives Facilities

In addition to the requirements of Chapter II Section 7.5 of DOE/EV 06194, a resilient floor covering shall be installed in all HE bays (including explosives-plutonium bays) where uncased HE components are handled. Open joints that might trap HE particles shall be avoided. The resilient floor covering used shall be one that has been found to be acceptable in either the LANL or LLNL skid tests. Information can be obtained from the WX Division, LANL, or the Hazards Control Department, LLNL.

0980 SPECIAL COATINGS

Special coatings shall comply with the following guides:

- AA Aluminum Finishes for Architecture
- AA Finishes for Aluminum in Building
- NAAMM Metal Finishes Manual
- PCA Clear Coatings for Exposed Architectural Concrete
- PCA Effect of Substances on Concrete and Guide to Protective Treatment
- PCA Surface Treatments for Concrete Floors
- NCMA Waterproofing Coatings for Concrete Masonry
- ACI Guide to the Use of Waterproofing, Dampproofing, Protective, and Decorative Barrier Systems for Concrete

0990 PAINTING

Painting shall comply with PDCA Architectural Painting and Wall Covering Manual.

Painting of concrete shall comply with PCA Painting Concrete.

0995 WALL COVERINGS

Wall coverings shall conform to NFPA 101.

Painting shall comply with PDCA Architectural Painting and Wall Covering Manual.

Division 10
Specialties

1015 COMPARTMENTS AND CUBICLES

Where significant moisture is normally present (such as in shower rooms, drying rooms, and dishwashing rooms), compartments and cubicles shall not use the following:

- Hardboard facings
- Unimpregnated paper honeycomb cores
- Paper honeycomb cores with foam plastic fill or vermiculite fill

1020 LOUVERS AND VENTS

Lowers and vents located in potentially corrosive environments, such as in close proximity to saltwater or in areas of acid rain, shall be corrosion-resistant or protected against corrosion.

For louvers and vents that are a part of a mechanical system, see Division 15, Mechanical.

1024 GRILLES AND SCREENS

Grilles and screens located in potentially corrosive environments, such as in close proximity to saltwater or in areas of acid rain, shall be corrosion-resistant or protected against corrosion.

For grilles and screens that are a part of a mechanical system, see Division 15, Mechanical.

1027 ACCESS FLOORING

An LCC analysis of raked access flooring shall be made to determine its use.

The design and construction of raised access flooring shall comply with UBC Chapter 23 and DOE/EP 0108.

A continuous IAS shall be provided for occupiable spaces below raised access flooring within protected areas and, as required by the site-specific security plan, within limited and exclusion areas.

1030 FIREPLACES AND STOVES

Fireplaces and stoves shall be tested and listed by UL or similar nationally accredited testing laboratories.

1040 IDENTIFYING DEVICES

1040-1 GENERAL

Identifying devices for buildings and facilities, including site and street facilities, shall comply with the DOE Design Guide. This standard shall not apply to displays or related areas in the graphic arts.

Identifying devices shall be informational and shall provide direction, identification, and regulation.

To accommodate future changes, identifying devices shall incorporate flexibility, and identifying device components and materials shall be commercially available, nonproprietary products.

Exterior identifyng devices located in potentially corrosive environments, such as in close proximity to saltwater or in areas of acid rain, shall be corrosion-resistant or protected against corrosion.

1040.2 NAMING DOE BUILDINGS AFTER INDIVIDUALS

The individual or individuals for which the building is named must be deceased.

The individual or individuals for which the building will be named shall be preeminent persons who have contributed substantially to the advancement of the activities being performed in the building, to the functional areas for which the site is responsible, or to other related fields where some relationship to the activity or to the site can be established.

The chain of approval shall be as follows: 1) nomination by the Director of the site, 2) concurrence by the DOE Operations Office Manager, 3) concurrence by the Headquarters program sponsor office, 4) concurrent by Congressional Affairs to determine if any Congressional notification is necessary, and 5) approval by the Secretary of Energy. All Headquarters action shall be coordinated by the Director of Administration.

1050 LOCKERS

Where significant moisture is normally present (such as in shower rooms, drying rooms, and dishwashing rooms), lockers shall not use the following

- Hardboard facings
- Unimpregnated paper honeycomb cores
- Paper honeycomb cores with foam plastic fill or vermiculite fill

1052 FIRE PROTECTION SPECIALTIES

Fire protection specialties shall be tested and listed by UL or similar nationally accredited testing laboratories or approved by FM or similar national insurance organizations.

Requirements for portable fire extinguishers appear in Section 1530-7, Portable Fire Extinguishers.

1053 PROTECTIVE COVERS

Protective covers located in potentially corrosive environments, such as in close proximity to saltwater or in areas of acid rain, shall be corrosion-resistant or protected against corrosion.

1055 POSTAL SPECIALTIES

USPS standards shall govern the selection and installation of postal equipment to be used by USPS.

1060 PARTITIONS

Where significant moisture is normally present (such as in shower rooms, drying rooms, and dishwashing rooms), partitions shall not use the following:

- Hardboard facings
- Unimpregnated paper honeycomb cores
- Paper honeycomb cores with foam plastic fill or vermiculite fill

1065 OPERABLE PARTITIONS

Where significant moisture is normally present (such as in shower rooms, drying rooms, and dishwashing rooms), operable partitions shall not use the following

- Hardboard facing
- Unimpregnated paper honeycomb cores
- Paper honeycomb cores with foam plastic fill or vermiculite fill

Operable partitions shall comply with Division 9, Finishes, and Section 1260, Furniture and Accessories.

1070 EXTERIOR SUN CONTROL DEVICES

The type and use of exterior sun control devices for natural illumination and solar control shall be determined in the energy conservation analysis discussed in Section 0110-12, Energy Conservation.

Exterior sun control devices located in potentially corrosive environments, such as in close proximity to saltwater or in areas of acid rain, shall be corrosive-resistant or protected against corrosion.

1075 TELEPHONE FACILITIES

Telephone specialties shall be listed by UL or similar nationally accredited testing laboratories.

1080 TOILET AND BATH ACCESSORIES

In public and employee toilet rooms, accessories attached to toilet partitions shall be through-bolted to partitions.

Die-cast zinc alloy accessories shall not be used, except as toilet paper holder doors.

Only double toilet tissue holders shall be uesd.

In facilities required to be accessible to physially handicapped persons, bathroom accessories shall comply with UFAS.

Division 11
Equipment

1100 GENERAL

Equipment specifications shall reflect standard, commercially available equipment that allows a reasonable range of competitive bidding. At least three companies shall be capable of manufacturing equipment. In addition, major equipment, e.g., boilers and chillers, shall have had a satisfactory commercial or industrial operational experience of at least 6,000 operating hours prior to bid opening.

Special equipment that is not a standard product of a recognized manufacturer or is not offered competitively shall not be used unless it complies with 48 CFR 10.

Full-load and part-load energy efficiencies shall be given special consideration in evaluating equipment performance. (Refer to ASHRAE Standard 90 and Section 0110-12, Energy Conservation).

All air-conditioning equipment shall comply with applicable ARI standards as a minimum requirement.

1161 ENCLOSURES

1161-1 GENERAL CONSIDERATIONS

Enclosures as used here are physical barriers (eg., cubicles, gloveboxes, fume hoods, conveyor tunnels) that, together with their ventilation and operating systems, prevent the release of radioactive or other hazardous material to the work space or the environment. Accordingly, their structural and confinement integrity shall be primary design consideration.

DOE project manager shall provide the design professional criteria on the location, size, fume imposition, and operating schedule for enclosures. Unless more specific design guidance is provided to the design professional from DOE project manager, the primary reference source shall be the ACGIH Industrial Ventilation Manual.

The design objective shall be to prevent exposure of the plant personnel to airborne contamination and shall implement ALARA concepts as practical to minimize operator exposures. The enclosure system, including its internal and external support structures, shall be designed to withstand the effects of normal operating conditions and the environment. Also, DBAs such as fire, explosion, criticality, and natural phenomena shall be considered in the design of the enclosure. Enclosure stability during a seismic event shall be based on the seismic parameters described in Section 0111-99.0.4, Earthquakes. The criticality considerations should include water or other liquid sources, potential liquid level in the enclosure (during operations or fire fighting), and drains to limit liquid level in the enclosure.

Where practical and without penetrating the enclosure, all equipment components not functionally required to operate directly in the presence of radioactive materials shall be located outside the enclosure. All equipment that must be located within the enclosure shall be designed to allow for in-place maintenance and/or replacement.

The design and operation of support and protection systems, such as fire protection, shall not promote the failure of the enclosure system integrity or the loss of confinement.

1161-2 CONSTRUCTION

Noncombustible or fire-resistant and corrosion-resistant materials shall be used for enclosures and, to the maximum extent practicable, for any required radiation shielding. In no case shall the total combustible loading located in a fire area exceed the fire resistance rating of the structural envelope (see Section 0110-99.0.6, Fire Resistance). This shall be documented in a fire risk analysis performed according to a methodology approved by the DOE Fire Protection Authority. This analysis should include estimated fire area combustible loadings, ventilation parameters, room dimensions, maximum average gas temperature, fire duration, maximum average heat flux, and the calculational method used. Enclosures (except open-face hoods) shall be designed with the objective of being leak-tight. In conjunction with their ventilation systems, all enclosures shall be capable of maintaining confinement (i.e., negative pressure with respect to the surrounding operating area). Without their associated ventilation systems enclosures shall be designed with appropriate physical features to provide an essentially leak-tight confinement (except open-face hoods, which shall provide filtered confinement) for the contaminants they handle.

Enclosure specifications should include the following standardized features, where applicable:

- Windows and mountings
- Glove ports (size, location and height)
- Ease of cleaning (radius corners, smooth interior and exterior surfaces, minimal protuberanas, and accessibility of all parts)
- Adequate interior illumination (from fixtures mounted on the exterior where feasible)
- Connections for services lines, conduits, instrument leads and ductwork
- Fire barriers and filter installation

- Sample removal ports
- Pressure differential readouts
- Attachments for interconnection of enclosures

Appropriately sized and located windows shall be part of the enclosure design to provide operators with visual access to the enclosure interior. Viewing windows in enclosures shall be as small as practicable. The windows shall be constricted of noncombustible or approved fire-resistant materials as specified in Section 0727, Firestopping. Consideration shall be given to resistance of the selected material to impact and radiation damage. The use of Mylar-glass laminates shall be considered for use as viewing windows and lighting fixture covers where hydrofluoric acid environments are present. Window design shall be such that it will enable replacement with minimum risk of releasing contamination to the working area. The selection of appropriate window material shall be based on specific process, combustible loading, and radiological safety considerations.

Glove ports shall be located to facilitate both operations and maintenance work inside the enclosure. They shall have flexible gloves attached to allow operating personnel access to all interior surfaces and equipment. They shall be designed to allow replacement of gloves without losing contamination control and with minimum exposure to the operator. When gloves are not in place, a noncombustible shield or cover for each glove port shall be provided.

To reduce migration of contamination, closure devices or permanent seals shall be provided on entrances and exits of piping, ducts, or conduits penetrating confinement barriers. Such closures or seals shall have an integrity equal to or greater than the barrier itself.

Where pertinent to safety, the enclosure design shall consider the heat generation in the enclosure. Such heat sources may be from processes, lighting, and the decay of radioactive material. Consideration of radioactive material as a heat source is particularly applicable to storage enclosures.

Consideration shall be given to incorporating transfer systems such as a double-door, sealed transfer system for removal of hazardous material from a glove box. Various types of removal and transfer systems appear in IAEA Safety Series No. 30. These systems are designed to allow entry and removal of material without breaching the integrity of the glove box.

Consideration shall be given to modular instruction, versatility, relocation, and incorporation of shielding. Structural support shall be provided to accommodate any anticipated loading resulting from shielding. The design professional shall consider techniques for limiting size to anticipate limitations on the dimensions of packing crates for disposal (e.g., current DOE criteria limit the size of TRU containers that will be accepted at the WIPP repository to 4 ft. x 4 ft. x 7 ft.).

Discrete work stations or process areas shall be separated from each other by a barrier designed to prevent the spread of fire based on safety analysis review. Generally, the fire barriers within and between enclosures will be normally closed. Where operations require that the fire barrier be in the open position, it shall automatically close on activation of the fire detection system or by release of a fusible device. Design of the enclosure system shall allow automatic closure of the fire barrier without loss of confinement, without degradation of the enclosure system's integrity, and without injury to personnel. The fire barrier shall be capable of being opened or closed manually from the exterior and interior of the enclosure. Allowable open area around a fire barrier shall be minimized.

1161-3 FIRE PROTECTION

Automatic fire suppression provisions shall comply with Section 1530-99, Special Facilities. When an automatic fire suppression system is mandatory and protection against loss from fire originating within the enclosure system is required, a highly reliable, fast-acting system shall be provided. Instead of such a system, an inert atmosphere can be used within the enclosure, provided its reliability is commensurate with an approved fire suppression system (e.g., dedicated gas supply, component quality, and redundancy where appropriate). The oxygen concentration shall be less than the minimum concentration that would allow ignition or combustion of the enclosure contents. Where automatic systems are not required, fire detection shall be installed. Provisions shall also be made for manual fire suppression where deemed necessary. Fire detection systems shall be integrated with any central alarm location and any associated automatic fire suppression systems.

1161-4 VENTILATION

A ventilation system shall be installed on all enclosure systems to maintain a minimum negative pressure differential of 0.3 in. of water inside the enclosure (except open-face hoods) with respect to the operating area. Open-face hoods shall be ventilated such that flow from the operating area into the hood is maintained. Safety class items of the ventilation system shall be supplied with emergency power. Failure of any single component or control function shall not compromise minimum adequate ventilation. The design professional shall consider the possible necessity to remove moisture, heat, and explosive and corrosive gases, as well as other contaminants. Perchloric acid fume exhaust systems shall comply with NFPA 45, Chapter 6.

HEPA filters shall be provided at the interface of the enclosure outlet and the ventilation system to minimize the contamination of ductwork and at the enclosure inlet to prevent movement of contamination within the enclosure to the operating area in the event of a flow reversal. A roughing filter should be installed to reduce HEPA filter loading. The system shall be designed to automatically ensure adequate inflow of air through a credible breach in the enclosure system. Minimum inward air velocity shall be 125 plus or minus 25 linear ft/min or as determined from guidance provided in the ACGIH Industrial Ventilation Manual The design of the enclosure ventilation flow pattern shall minimize the spread of fire, and fire screens shall be provided where necessary.

For enclosures where overpressurization is possible, a system shall be provided to ensure that confinement is not breached. Small enclosure systems with positive-pressure supplied gases shall have positive-acting, pressure-relief devices (connected into the exhaust system) to prevent pressurization of the enclosure.

Hood faces shall not be located within 10 ft. of the closest air supply or exhaust point. Hoods shall not be located in or along normal traffic routes. An open-faced hood shall be designed and located to provide a minimum air velocity of 125 plus or minus 25 linear ft/min over the hood face area. A hood should not be used in a location where room air currents of >50 linear ft/min at the face of the hood will disrupt uniform air entrance. All open-face hoods shall be designed to provide appropriate face velocity to ensure capture of contaminants in the hood exhaust (see the ACGIH Industrial Ventilation Manual). Exhaust air from a hood shall not be recirculated to occupied areas.

1161-5 OPERATIONAL COMPATIBILITY

Shielding, shape, size, and any other pertinent design criteria for all enclosures, glove boxes, conveyor tunnels, hoods, and process equipment should be coordinated with operations requirements to ensure continuity and performance of operations; and by the Safeguards and Security Group (function) to ensure that SNM control and accountability considerations have been considered along with other DOE physical protection requirements (DOE 5632 series).

Division 12
Furnishings

1201 GENERAL

The renewal of fire retardant coatings as required by NFPA 101, Chapter 31, shall be included in LCC calculations.

Furnishings shall be designed and constructed to exclude or prevent the escape of emissions from volatile organic compounds, such as formaldehyde, and combinations of volatile organic compounds that have been determined to be a health hazard.

1230 MANUFACTURED CASEWORK

The design of manufactured casework shall consider competitive types using standard stock sizes, materials, and finishes; modules and dimensionally interchangeable elements; and construction tolerances.

The design of manufactured casework for use with radioactive materials shall consider radioactive shielding requirements.

1250 WINDOW TREATMENT

Window treatments shall comply with NFPA 101, Chapter 31.

The type and use of window treatments with respect to natural illumination and solar control shall be determined in the energy conservation analysis; see Section 0110-12, Energy Conservation, and Division 15, Mechanical.

Where window treatments are used as a part of the acoustical treatment, or are to be used where acoustical treatment is required, such as in open offices or landscaped offices, they shall be included in the acoustical analysis; see Section 0950, Acoustical Treatment.

1250-1 DRAPERY AND CURTAIN HARDWARE

Drapery and curtain hardware shall comply with UL 325.

1260 <u>FURNITURE AND ACCESSORIES</u>

1260-1 LANDSCAPE PARTITIONS AND COMPONENTS

Office landscape partitions and components shall comply with NFPA 101, Chapter 31, and UBC Chapter 17.

Where office landscape partitions and components are used, they shall be included in the acoustical analysis, see Section 0950, Acoustical Treatment. They shall also be included in the analysis and design of natural and artificial illumination; see Section 0110-12, Energy Conservation, and Section 1655, Interior Lighting.

Office landscape partitions and components shall be designed to accommodate task lighting when it is determined that task lighting is necessary; see Section 1655, Interior Lighting.

1260-2 FURNITURE

Furniture shall comply with NFPA 101, Chapter 31 (sections concerning finishings, decorations, and treated finishes), and UBC Chapter 17 for folding, portable, and movable partitions.

1260-3 FURNITURE SYSTEMS

Furniture systems shall comply with NFPA 101, Chapter 31 (sections concerning finishings, decorations, and treated finishes), and UBC Chapter 17 for folding, portable, and movable partitions.

Where furniture systems are used, they shall be included in the acoustical analysis, and in the analysis and design of natural and artificial illumination; see Section 0950, Acoustical Treatment, and Section 1655, Interior Lighting.

1260-4 RUGS AND MATS

Rugs and mats shall comply as furnishings with NFPA 101, Chapter 31 (sections concerning finishings, decorations, and treated finishes), in all occupancy classifications except those of storage and industrial.

Rugs and mats used in storage or industrial occupancies shall have a critical radiant flux not less than the following:

Division 13
Special Facilities

1300 GENERAL REQUIREMENTS

1300-1 COVERAGE AND OBJECTIVES

1300-1.1 Coverage

Special facilities as used in Division 13 include the following:

- Nuclear facilities as defined in the Glossary and in DOE 5480.5
- Explosives facilities

The criteria in this section of Division 13 (Section 1300, General Requirements) apply to all nonreactor nuclear facilities and to explosives facilities. Subsequent sections provide additional criteria that are applicable to specific types of nonreactor nuclear facilities and to explosives facilities. (Reactors and their safety systems shall be sited and designed according to DOE 5480.6.)

There may be some facilities for which these criteria are not sufficient and for which additional criteria must be satisfied in the interest of safety. Also, some criteria may be determined by safety analysis to be unnecessary or inappropriate for a specific facility. For facilities such as these, departures from the criteria shall be identified and justified. See Section 0101-2, Criteria Deviations.

1300-1.2 Using Division 13

The other divisions of these criteria correspond to the CSI MASTERFORMAT organization, which reflects the major building systems and design specialties. Criteria for special facilities in those divisions appear under a "-99" system. For example, Division 15, Mechanical, contains mechanical criteria that apply to all DOE facilities, both non-special and special. Mechanical criteria for all facilities are numbered 15xx. In addition, mechanical criteria that apply only to special facilities are numbered 15xx-99.

Within the -99 sections in the various divisions, facility types are designated by the following numbers:

- 99.0, Nonreactor Nuclear Facilities–General

- 99.1, Laboratory Facilities (Including Hot Laboratories)
- 99.2, Emergency Preparedness Facilities
- 99.3, Plutonium Processing and Handling Facilities
- 99.4, Explosives Facilities
- 99.5, Unirradiatad Enriched Uranium Storage Facilities
- 99.6, Plutonium Storage Facilities
- 99.7, Occupational Health Facilities
- 99.8, Telecommunications, Alarm, and ADP Centers and Radio Repeater Stations
- 99.9, Vaults and Vault-Type Rooms for Storage of Classified Matter
- 99. 10, Secure Conference Rooms
- 99.11, Secure Offices
- 99.12, Uranium Enrichment Facilities
- 99.13, Uranium Processing and Handling Facilities
- 99.14, Irradiated Fissile Material Storage Facilities
- 99.15, Reprocessing Facilities
- 99.16, Uranium Conversion and Recovery Facilities
- 99.17, Radioactive Liquid Waste Facilities
- 99.18, Radioactive Solid Waste Facilities
- 99.19, Tritium Facilities
- 99.20, Fusion Facilities

The remaining sections of Division 13 cover nonreactor nuclear facilities (which as used here includes laboratory facilities/hot laboratories) and explosives facilities criteria that do not relate to the major building systems or other design specialties covered in the other divisions. When designing these facilities, Division 13 criteria shall be applied in addition to applicable criteria in other divisions.

Design criteria for nonreactor nuclear facilities and explosives facilities thus appear in three places:

- In the conventional sections of the other criteria divisions-e.g., Section 1550 provides criteria on HVAC systems that apply to all DOE facilities.

- In the -99.0, -99.1, and -99.4 sections of the non-Division 13 divisions-e.g., Sections 1550-99.0 and 1550-99.4 provide additional criteria on HVAC systems that apply only to nonreactor nuclear facilities and explosives facilities, respectively.

- In Division 13-e.g., special criteria that do not relate to the building systems and design specialties covered in the other criteria divisions

See Section 0101-3, Organization and Use of These Criteria.

1300-1.3 Objectives

The design of special facilities shall:

- Protect the public and facility personnel from hazards associated with the use of radioactive and other hazardous materials as a result of normal operations, anticipated operational occurrences, and DBA conditions, including the effects of natural phenomena pertinent to the site, and maintain these effects ALARA

- Ensure compliance with DOE policies regarding nuclear safety, criticality safety, radiation safety, explosives safety, industrial safety, fire protection, environmental protection, and Safeguards and Security (S&S) protection for special nuclear material

- Protect government property and essential operations from the effects of potential accidents

- Minimize exposures of personnel and the general public to hazardous materials by emphasizing ALARA concerns during all design, construction, and operational phases of special facilities

The design of new or modification of existing special facilities shall address the health hazards represented by all hazardous materials in enclosures, general work areas, and noncontaminated areas.

The release of hazardous materials under normal operating conditions and anticipated operational upset occurrences shall be designed to be less than release guideline limits contained in applicable orders, regulations, and requirements. In addition, to the extent practical, such releases shall be maintained ALARA.

Consideration shall be given to the frequency of occurrence and the effects of DBAs in the design features of special facilities. The depth of the risk analysis involved in this consideration should be in some measure proportional to the level of risk at the facility under consideration.

Protection of employees within the facility and at nearby facilities shall be a requirement in all aspects of the design. Protection shall be provided for normal operation and for those accidents that can be anticipated as occurring during the facility lifetime such as radioactive material spills and small fires controlled by the facility fire suppression system. Occupational exposure to radiation shall be limited according to DOE 5480.11. Design goals shall be established to maintain radiation exposure of employees ALARA. The nature of the hazardous materials in the facility, including radionuclides, shall be considered in the assessment of potential employee exposure.

For mixed-use facilities, such as those combining PPHFs and PSFs, the design of either part of that facility shall not jeopardize the safety requirements of the other.

1300-1.4 Guidance on Limiting Exposure of the Public

1300-1.4.1 General

The confinement of hazardous materials produced, processed, or stored in special facilities shall be designed to minimize dose to a maximally exposed member of the public.

1300-1.4.2 Accidental Releases

Releases of hazardous materials postulated to occur as a result of DBAs shall be limited by designing facilities such that at least one confinement system remains fully functional following any credible DBA (i.e., unfiltered/unmitigated releases of hazardous levels of such materials shall not be allowed following such accidents). Facility design shall provide attenuation features for postulated accidents (up to and including DBAs) that preclude offsite releases that would cause doses in excess of the DOE 5400 series limits for public exposure. To the extent practical, ALARA concepts shall be applied when designing special facilities to mitigate post-DBA releases of hazardous materials. For facilities whose hazard potential is determined to be extremely low, deviations from the criteria of this section may be considered in accordance with Section 0101-2, Criteria Deviations.

1300-1.4.3 Routine Releases

The annual dose resulting from postulated, planned, or expected releases from the proposed facility shall be considered in combination with the annual doses resulting from planned or expected releases from other facilities at the same site. The sum of the doses from the site shall be limited according to DOE Radiation Standards of Protection of the Public in the Vicinity of DOE Facilities or subsequent guidance included in the directive on Radiation Protection of the Public and the Environment in the DOE 5400 series.

1300-1.4.4 Monitoring of Releases

Releases shall be monitored in accordance with the directive on Radiological Effluent Monitoring and Environmental Surveillance in the DOE 5400 series.

1300-2 SAFETY ANALYSIS

Safety analysis shall comply with DOE 5481.1B. See also Section 0110-5.2, Safety Analysis.

1300-3 SAFETY CLASS CRITERIA

1300-3.1 General

Special facility components, systems, and structures shall be designed, fabricated, erected, and tested to standards and quality commensurate with the hazards and potential consequences associated with both the facility and the role of each component, system, and structure in mitigating the consequences of DBAs.

1300-3.2 Safety Class Items

Safety class items are systems, components, and structures, including portions of process systems, whose failure could adversely affect the environment or the safety and health of the public. Specifically, safety class items are those systems, components, and structures with the following characteristics:

- Those whose failure would produce exposure consequences that would exceed the guidelines in Section 1300-1.4, Guidance on Limiting Exposure of the Public, at the site boundary or nearest point of public access
- Those required to maintain operating parameters within the safety limits specified in the OSRs during normal operations and anticipated operational occurrences
- Those required for nuclear criticality safety
- Those required to monitor the release of radioactive materials to the environment during and after a DBA
- Those required to achieve and maintain the facility in a safe shutdown condition
- Those that control the safety class items described above

DOE/TIC 11603, Rev. 1, presents examples of safety classification of plant systems, structures, and components in its appendixes, however, for comparable sections in DOE/TIC 11603, Rev. 1, and DOE 6430.1A. the design criteria in DOE 6430.1A shall govern.

Safety class items shall be subject to appropriately higher-quality design, fabrication, and industrial test standards and codes such as those specified in Section 0106, Regulatory Requirements, and Section 0109, Reference Standards and Guides, to increase the reliability of the item and allow credit to be taken for its capabilities in a safety analysis. Safety class items shall be designed to the ASME Boiler and Pressure Vessel Code (Section III, Class II) or to other comparable safety-related codes and standards that are appropriate for the system being designed.

Safety class and non-safety class items shall comply with Section 0140, Quality Assurance. The design of systems, components and structures that are not safety class items shall, as a minimum, be subject to conventional industrial design standards, codes, and quality standards. Failure of these items shall not adversely affect the environment or the safety and health of the public. In addition, their failure shall not prevent safety class items from performing their required functions.

1300-3.3 Single Failure Criterion and Redundancy

The design shall ensure that a single failure (see Glossary) does not result in the loss of capability of a safety class system to accomplish its required safety functions. To protect against single failures, the design shall include appropriate redundancy and shall consider diversity to minimize the possibility of concurrent common-mode failures of redundant items.

1300-3.4 Equipment Environment Considerations

1300-3.4.1 General

Safety class items shall be designed to withstand the effects of, and be compatible with, the environmental conditions associated with operation, maintenance, shutdown, testing, and accidents. The environmental capability of equipment shall be demonstrated by appropriate testing, analysis, and operating experience, or other methods that can be supported by auditable documentation, or a combination of these methods.

1300-3.4.2 Environmental Qualification of Equipment

Equipment qualification shall provide assurance that safety class items will be capable of performing required safety functions under DBA conditions. The qualification shall demonstrate that the equipment can at least perform for the period of time that its safety functions are required. Subsequent equipment failure, after its safety function is no longer required, may be allowable.

Temperature, pressure, and humidity environments shall be based on the most severe postulated accident affecting the particular item. The postulated environment shall reflect an environment that considers both radiological composition (e.g., elements, isotopics, total radioactivity) and chemical composition (e.g., abrasives, acids, smoke, caustic vapors) of all material physical forms likely to affect the equipment.

1300-3.4.3 Equipment Operability Qualification

Testing or a combination of testing and analysis shall be the preferred method of demonstrating the operability of fluid system components, mechanical equipment, instrumentation, and electrical equipment that are required to operate during and following a DBE. Seismic experience data may be used as an alternative to testing or dynamic analysis where. such data have been documented and validated. See Section 0111-99.0, Nonreactor Nuclear Facilities-General.

1300-3.5 Maintenance

The design shall consider the maintainability factors peculiar to the specific equipment to be used in the facility. Facility design shall provide for routine maintenance, repair, or replacement of equipment subject to failure.

Safety class items shall be designed to allow inspection, maintenance, and testing to ensure their continued functioning, readiness for operation, and accuracy. Ancillary equipment, such as pumps, blowers, motors, compressors, gear trains, and controls, shall be located in an area least likely to be contaminated.

The design of equipment that must be located within confinement systems shall allow for in-place maintenance or replacement.

The capability shall be provided for the maintenance of contaminated equipment that cannot be repaired in place. This capability shall include the necessary provisions for confinement, ventilation, and waste control.

The design of all process equipment shall include features to minimize self-contamination of the equipment, piping, and confinement areas. The design of process equipment shall also include features to minimize the spread of contamination out of local areas.

1300-3.6 Testing

The design shall include provisions for periodic testing of monitoring, surveillance, and alarm systems. In addition, the design shall provide the capability to test periodically, under simulated emergency conditions, safety class items that are required to function under emergency conditions.

All systems for which credit is taken to meet the criteria of Section 1300-1.4.2, Accidental Releases, shall be in-place testable in terms of pressure, filtration or removal efficiency, alarm capability, leak resistance, and the like. Safety class items shall be designed to be testable on a regular schedule.

The facility design shall allow for routine in-place testing of HEPA filtration systems as outlined by ASME N510.

1300-4 NUCLEAR CRITICALITY SAFETY

An assessment of a design shall be made as early as practical to determine if the potential for nuclear criticality exists. When such potential exists, the design of nuclear criticality control provisions, including equipment and procedures, shall meet, as a minimum, the requirements of DOE 5480.5 and the ANS 8 series on Nuclear Criticality Safety.

Nuclear criticality safety shall be achieved by exercising control over both the quantity and distribution of all fissile materials and other materials capable of sustaining a chain reaction, and over the quantities, distributions, and nuclear properties of all other materials with which the fissile materials and other materials capable of sustaining a chain reaction are associated. Design considerations for establishing such controls shall be mass, density, geometry, moderation, reflection, enrichment, interaction, material types, and nuclear poison.

The design shall ensure that material shall not be displaced or allowed to accumulate to form a critical mass in the event of an internal or external accident. The design shall emphasize geometrically favorable compartments or spacing to minimize reliance on administrative control, and shall prevent the unsafe accumulation of moderator or reflection materials (e.g., water from a fire sprinkler system). Also, heating or cooling jackets in the safe dimension of geometrically safe vessels shall preclude a leak in the jacket that causes an increase in the system's reactivity.

Process designs shall incorporate sufficient factors of safety so that at least two unlikely and independent concurrent changes must occur in process conditions before a criticality accident is possible.

Structures, systems, and components that provide nuclear criticality safety shall be designed as safety class systems and be capable of performing their criticality safety functions during and following design basis accidents and events. A criticality monitoring and alarm system (gamma and/or neutron) shall be provided where necessary to meet the requirements of DOE 5480.5 and ANS 8.3.

Nuclear criticality safety shall be controlled, in decreasing priority, by geometric spacing, density and/or mass limitation, fixed neutron absorber, soluble neutron absorber, and administrative control. The design of the facility shall emphasize engineered safeguards and shall not rely strictly on administrative controls.

Process systems shall be designed to prevent the carryover of fissile material and other material capable of sustaining a chain reaction from geometrically favorable portions of the facility to other areas.

A system of positive control and backflow prevention, such as air gaps (siphon breakers) shall be used to prevent inadvertent transfer of fissile material and other material capable of sustaining a chain reaction from geometrically favorable or poisoned containers to unsafe containers.

Locations where a potential critical mass could occur in the event of accidental flooding by water from fire protection systems shall be protected by geometrically favorable curbed areas or collection systems.

Where frequency estimates for a specific operation at a specific location shows the frequency of a criticality accident to exceed 10-6 per year, the combination of shield design and facility layout shall minimize radiation doses to adjacent work stations and exit routes. Egress routes shall be provided that take into account the locations where postulated criticality accidents would normally be expected to occur. The design objective should be to provide escape routes that have the lowest potential for radiation exposure to exiting personnel. For facilities where the design cannot avoid evacuation through areas of potentially high exposure, the use of additional shielding in such areas shall be considered. All barriers along egress routes shall be designed to allow crash exiting of evacuating personnel (i.e., operator safety should take priority over security concerns).

1300-5 SOURCE AND SPECIAL NUCLEAR MATERIAL

When the safety analysis identifies the source and SNM that will be handled, the criteria for the most hazardous material shall be applied to the design. The criteria of ANSI N16.1 shall apply. In-process source or SNM shall be stored in storage containers to be approved by facility management, and simple physical barriers shall be used to segregate materials and provide a level of confinement and safety consistent with the hazard of the material. See also

Section 1300-10, Physical Protection, Material Safeguards, and Storage of Special Nuclear Material.

1300-6 RADIATION PROTECTION

1300-6.1 General

Special facilities shall be designed to minimize personnel exposures to external and internal radiological hazards, provide adequate radiation monitoring and alarm systems, and provide adequate space for health physics activities. Primary radiation protection shall be provided by the use of engineered controls (e.g., confinement, ventilation, remote handling, equipment layout, and shielding); secondary radiation protection shall be provided by administrative control. ALARA concepts shall be applied to minimize exposures where cost-effective.

1300-6.2 Shielding Design

The shielding design basis shall be to limit the maximum exposure to an individual worker to one-fifth of the annual occupational external exposure limits specified in DOE 5480.11. Within this design basis, personnel exposures shall be maintained ALARA. Specifically, the shielding shall be designed with the objective of limiting the total EDE to less than 1 rem per year to workers, based on their predicted exposure time in the normally occupied area. The EDE shall be the sum of all contributing external penetrating radiation (gamma and neutron), In addition, appropriate shielding shall be installed, if necessary, to minimize nonpenetrating external radiation exposures to the skin and lens of the eye of the worker. In most cases, the confinement barrier or process equipment provides this shielding.

Shielding and other radiation protection measures shall be provided for areas requiring intermittent access, such as for preventive maintenance, component changes, adjustment of systems and equipment, and so forth. The projected dose rates based on occupancy, time, and frequency of exposure shall not exceed 1 rem/y.

Concrete radiation shielding design shall comply with ANS 6.4 and ACI 349 and shall consider the material specifications of ANS 6.4.2 where it provides a critical confinement or structural function. For other shields, ACI 318 is appropriate and provides adequate strength for DBE loads.

Straightline penetration of shield walls shall be avoided to prevent radiation streaming.

1300-6.3 Hand and Forearm Protection

Remote shielded operation (i.e., with remote handling equipment such as remote manipulators) shall be considered where it is anticipated that exposures to hands and forearms would otherwise approach the dose guidance in 5480.11 or where contaminated puncture wounds could occur.

1300-6.4 Internal Radiation Exposure

The design shall ensure that occupied operating areas do not exceed the airborne concentration limits of the DOE 5480 series for normal operating conditions. In addition, to the extent practical, the concept of ALARA shall be used when designing confinement and ventilation systems to limit airborne contamination levels. The design shall ensure that respirators are not required to meet the dose limits for normal operations. Engineered controls and features shall also be provided to minimize potential inhalation of radioactive and other hazardous materials under all conditions.

1300-6.5 Monitoring Warning and Alarm Systems

1300-6.5.1 General

All monitoring systems shall be calibrated annually with appropriate national standards to ensure validity of reported values. Environmental monitoring is discussed in Section 1300-9, Effluent Control and Monitoring. All radiation monitoring, alarm, and warning systems that are required to function during a loss of normal power shall be provided with an emergency UPS (internal or external on-line) unless it is demonstrated that they can tolerate a temporary loss of function without losing needed data and they are provided with standby or emergency (switched) power. Determination of the power supply type and quality shall be based on the safety classification of the monitoring system or device. The sampling motivation (vacuum) shall be installed to the same requirement.

1300-6.5.2 Air Monitoring and Warning Systems

Air monitoring and warning systems shall be installed in work areas where hazardous materials are stored or handled and where hazardous airborne particles or vapors may be present. Air sampling heads shall be located to provide a representative sample of potential airborne radioactive materials being breathed. Air monitoring systems shall comply with ANSI N13.1.

1300-6.5.3 Personnel Monitoring and Warning Devices

Use of devices to warn personnel of possible contamination or other hazardous materials shall be evaluated and such devices shall be provided in accordance with this evaluation. Provisions shall be made for personnel monitoring devices, such as hand and foot counters, in the vicinity of work stations. Installed monitors (supplemented with personal monitoring methods if necessary) shall be used to monitor personnel exiting an operating area through access ways. CAMSs shall be provided to detect and to alarm at prescribed airborne radioactivity levels.

1300-6.5.4 Ionizing Radiation Monitoring System

Where ionizing radiation is present (due to process material, equipment, or operations), an area radiation monitoring and alarm system shall be provided to alert personnel of unexpected increases in ionizing radiation levels.

1300-6.5.5 Warning and Alarm System Features

Warning and alarm systems shall be designed, installed, and tested to ensure that they can be heard in the ambient conditions of the area they are intended to cover. Evacuation alarm systems shall comply with ANSI N2.3.

1300-6.5.6 Nuclear Accident Dosimetry

Where there k the potential for a criticality excursion causing personnel exposures, nuclear accident dosimeters shall be provided with performance features and placement consistent with DOE 5480.11.

1300-6.5.7 Central Radiation Monitoring and Alarm Readout

In addition to a local station alarm, radiation monitoring systems (criticality alarms, CAMSs, alarms associated with stack monitoring systems, and so on) shall have central (i.e., control room or radiation monitoring office) readout and alarm panels that are accessible after a DBA to evaluate internal conditions.

1300-6.6 Decontamination of Personnel

Design shall provide for personnel decontamination facilities close to areas that represent sources of potential contamination.

1300-6.7 Meteorological Equipment

Meteorological equipment shall be provided to measure and record wind speed and direction. Cosideration shall be given to the need for additional equipment to provide meteorological parameters such as humidity data and wind direction frequencies for heights related to the estimated heights at which stack effluents and cooling tower moisture will be dispersed. As necessary, special equipment for stack effluent dispersal and tracking shall be considered for installation. Central site meteorological monitoring capability shall be considered as a substitute for individual facility monitoring.

1300-6.8 Charge Rooms

Men's and women's change rooms shall be provided for changing into and from protective clothing. These areas shall be adjacent to shower facilities. Change rooms shall be designed to ensure that clean clothing (e.g., personal clothing) and protective clothing are segregated. The design shall ensure that storage of contaminated protective clothing will control contamination so that it does not spread beyond the storage container. The change room exhaust air shall be HEPA-filtered if dispersible radionuclides are handled in the process areas it serves.

1300-6.9 Breathing Air System

Operation and maintenance of special facilities may lead to situations (e.g., accidents, special maintenance, spill recovery) where air-supplied respiratory protection is required. Breathing air supply systems shall comply with ANSI Z88.2 and 29 CFR 1910.134.

1300-7 CONFINEMENT SYSTEMS

1300-7.1 Objectives

Confinement systems shall accomplish the following:

- Minimize the spread of radioactive and other hazardous materials within the unoccupied process areas
- Prevent, if possible, or else minimize the spread of radioactive and other hazardous materials to occupied areas
- Minimize the release of radioactive and other hazardous materials in facility effluents during normal operation and anticipated operational occurrences
- Limit the release of radioactive and other hazardous materials resulting from DBAs including severe natural phenomena and man-made events in compliance with the guidelines contained in Section 1300-1.4.2, Accidental Releases.

1300-7.2 General

Confinement capabilities, including confinement barriers and associated ventilation systems, shall maintain a controlled, continuous airflow pattern from the environment into the confinement building, and then from noncontaminated areas of the building to potentially contaminated areas, and then to normally contaminated areas.

For a specific nuclear facility, the number and arrangement of confinement barriers and their required design features and characteristics shall be determined on a case-by-case basis. Typical factors that affect confinement system design are the type, quantity, form, and conditions for dispersing the hazardous material, including the type and severity of DBAs. In addition, alternative process and facility designs may reduce the potential hazards and the requirements for confinement system design. Engineering evaluations, trade-offs, and experience shall be used to develop a practical design that achieves confinement system objectives.

The number of confinement systems required in different locations of a facility may vary depending on the potential consequences from hazards during normal operation, anticipated operational occurrences, and DBAs. Although individual confinement systems are not required to withstand the effects of every accident, they shall effectively perform their required functions for the DBAs they are required to withstand. Sufficient redundancy shall be provided in the unlikely event of a confinement system failure. At least one of the confinement systems shall be designed to ensure that it can withstand the effects of severe natural phenomena and man-made events (see Section 0111-99.0, Nonreactor Nuclear Facilities-General), including the postulated DBAs and DBF initiated by these events, and remain functional to the extent that the guidelines of Section 1300-1.4.2 Accidental Releases, are not violated. The adequacy of the design of these confinement systems to effectively perform their required functions shall be demonstrated by the safety analysis. To the extent practical, the ALARA concept shall be applied to the design of all confinement systems to minimize exposures to hazardous materials.

Because the number and arrangement of confinement systems that shall be required for a specific nuclear facility design cannot be predicted, these general criteria describe a conservative confinement design that uses three principal confinement systems. In general, the primary confinement system consists of the process enclosures and their ventilation system. In special cases where the processes require the use of corrosive or noxious materials the process system shall be totally enclosed (ie., pipes and vessels) and provided with its own ventilation and off-gas cleanup system. In such cases, the process system shall be treated as the primary confinement system. The secondary confinement system consists of the barriers that enclose the areas that house the primary confinement and the system that ventilates those areas. These areas may be referred to as operating areas or operating area compartments. The tertiary or final confinement system is the building structure and its ventilation system.

The secondary and tertiary barriers may exist in common such as a single structural envelope (e.g., walls, roof slab, floor slab), provided the barrier can withstand the effects of man-made events and DBAs including the DBE, and does not contain access ways that allow the routine transfer of personnel, equipment, or materials directly from the exterior of the facility. Access ways into the interior of the single structural envelope are allowed, provided that entrance into the access way is gained from another level of confinement.

The confinement system requirements specified for the various types of nuclear facilities in the facility-specific sections that follow are typical for that type of nuclear facility. The actual confinement system design requirements shall be determined as described in this section.

Design of confinement areas shall provide adequate means for decontamination of the areas prior to entry or breaching for maintenance and repair purposes.

Confinement system ventilation and off-gas system requirements are provided in Section 1550-99, Special Facilities, For enclosure of radioactive and other hazardous materials, see Section 1161, Enclosures.

1300-7.3 Access Ways

Special features (e.g., air locks, enclosed vestibulea) shall be considered for access through confinement barriers to minimize the impact of facility access requirements on the ventilation system and to prevent the release of radioactive airborne materials. Provision for normal and emergency equipment shall be provided in or adjacent to the access ways. Consideration shall be given to emergency lighting, paging systems, automatic access door switches, hand and foot monitors, storage for clothing and emergency equipment, warning lights, air sampling, and breathing air outlets.

1300-7.4 Transfer Pipes and Encasements

Double-walled pipes or pipes within a secondary confinement structure encasement shall be used in all areas where the primary pipe leaves the facility. In areas within the facility, the use of double-walled pipe shall be considered. Leakage monitoring shall be provided to detect leakage into the space between the primary pipe and the secondary confinement barrier.

1300-8 WASTE MANAGEMENT

1300-8.1 General

Wastes from special facilities may include both radioactive and nonradioactive materials and may be in the form of liquid or airborne effluents, or solids. For SNM declared to be waste, the term "wastes" shall be defined in accordance with the DOE 5632 series. The process systems shall minimize the production of wastes at the sources and minimize the mixing of radioactive and nonradioactive hazardous wastes. The waste management systems shall provide facilities and equipment (or incorporate existing facilities and equipment) to handle those wastes safely and effectively. Volume reduction equipment for both liquid and solid wastes shall be required where feasible and shall be designed for process capability and capacity commensurate with the types and quantities of wastes expected. Waste handling areas shall comply with the standards of confinement and ventilation requirements commensurate with the potential for spreading contamination by the waste packages/forms handled. Specific DOE design and operating requirements for radioactive wastes (HLW, LLW, and TRU) appear in DOE 5820.2A.

See also Section 0273, Water Pollution Controls; Section 0275, Industrial Wastewater Treatment; Section 0285, Solid Waste Systems; Section 1540, Plumbing and Service Piping; and Section 1589, Air Pollution Control.

1300-8.2 Hazardous Waste Requirements

Hazardous waste requirements appear in the directive in DOE 5480.1B, Chapter 2. Additionally, the RCRA, as amended, 40 CFR 264 and 40 CFR 265, contain specific design and operating requirements and standards for owners and operators of hazardous waste TSD facilities. Part 267 of RCRA contains interim standards for owners and operators of new hazardous waste land disposal facilities. Part 268 of RCRA contains land disposal restrictions and treatment standards for hazardous waste.

1300-8.3 Mixed Waste

Radioactive mixed waste, i.e., waste containing radioactive materials and other hazardous waste, shall be avoided where practicable. Mixed waste that cannot be avoided shall be identified and considered in the design at the earliest possible time. Mixed waste shall be segregated and handled separately from other types of waste in accordance with DOE 5400.3.

1300-8.4 Waste Segregation

Facility design shall provide for the segregation of hazardous wastes into compatible groups for storage in accordance with the DOE 5400 series and DOE 5480 series. Suggested compatibility groups are acids, caustics, flammable materials, and organic materials.

1300-8.5 Spill Prevention and Control

Spill prevention and control shall be considered in the design stage of the facility to minimize the possibility of accidentally releasing hazardous waste to the environment.

1300-8.6 Approvals and Permits

The construction of a new facility or modification of an existing facility that either releases hazardous wastes (including airborne radioactive effluents (see 40 CFR 61, Subpart H) to the environment or manages hazardous wastes shall in most cases be approved by the EPA or authorized State agency prior to the beginning of construction In addition to obtaining approval for construction or modification of a facility, operating permits shall also be obtained for facilities that manage hazardous wastes as specified in RCRA.

Environmental discharges of any effluent, including hazardous and nonhazardous wastes, shall meet applicable Federal and State laws and regulations and DOE orders. The limits specified in discharge permits for these effluents shall be considered during the design of the facility.

1300-9 EFFLUENT CONTROL AND MONITORING

Routine wastes from special facilities will normally be in the form of solids, liquids, and gases. The waste management systems shall provide facilities and equipment to handle these wastes safely, effectively, and in an environmentally responsible manner.

Hazardous effluents released to the environment (radioactive and nonradioactive) shall not exceed the limits referenced in DOE 5400.1 and the directive on Radiation Protection of the Public and the Environment in the DOE 5400 series. Emphasis shall be placed on reducing effluents released to the environment to ALARA levels using the best technology economically available at the time of design. Effluents shall comply with all applicable Federal, State, and local laws and regulations. State and local laws and regulations shall be carefully consulted, as they may provide more restrictive limits than Federal laws and regulations.

During normal operations, the effluent concentrations of radionuclides measured at the site boundary shall not exceed the DCGs specified in the directive on Radiation Protection of the Public and the Environment in the DOE 5400 series. At the point of discharge of the facility, i.e., stack or equivalent, the effluent concentration shall not exceed the DCGs specified in DOE 5480.11. The guidance on radiation protection referenced in Section 1300-1.4.3, Routine Releases, shall also apply to effluent treatment and discharge systems.

All effluent streams shall be sampled or monitored in accordance with the requirements of 5400.1, the directive on Radiation Protection of the Public and the Environment in the DOE 5400 series, and the directive on Radiological Effluent Monitoring and Environmental Surveillance in the DOE 5400 series. Sampling and monitoring shall ensure adequate and accurate measurements under normal operations, anticipated operational occurrences, and DBA conditions.

The design of the facility shall include appropriate groundwater monitoring unless a site-wide program is provided. This monitoring shall be designed to detect releases of contaminants to the ground or ground water. Groundwater protection programs shall comply with DOE 5400.1, DOE 5400.3, and the directive on Radiation Protection of the Public and the Environment in the DOE 5400 series.

See also Section 0273, Water Pollution Controls; Section 0275, Industrial Wastewater Treatment; Section 1540, Plumbing and Service Piping; and Section 1589, Air Pollution Control.

1300-10 PHYSICAL PROTECTION, MATERIAL SAFEGUARDS, AND STORAGE OF SPECIAL NUCLEAR MATERIAL

1300-10.1 General

The objective of safeguards and security systems is to protect SNM from theft or diversion and the material or facilities from sabotage. Safeguards and security systems are also designed to provide protection of classified material. Safeguards and security systems are concerned with malevolent activities that may be undertaken by both insider and outsider adversaries. Physical protection systems (see Section 1300-10.2, Physical Protection) are also integrated with material control and accountability systems (see Section 1300-10.3, Material Control and Accountability Safeguards) to provide a balanced safeguards and security system.

The safeguards and security system is designed to provide baseline protection against a potential threat essentially consisting of the following:

- A determined, violent, external assault, attack by stealth, or deceptive action by several persons or a small group
- An adversary group that is dedicated and well-trained in military skills and that may have the aid of an insider in either an active or passive role, suitable weapons, and hand-carried equipment such as explosives and tools for breaking barriers
- An internal threat of an insider, including any employee who may attempt SNM theft or sabotage, or a conspiracy of employees to commit such acts

More details are contained in the DOE Threat Statement.

The threat statement is meant to provide a basis from which to plan security system performance requirements and capabilities. Site-specific threat spectra should be developed by considering the generic threat guidance as well as various local and facility/site-specific factors.

Detailed requirements for physical protection and material control and accountability systems are contained in the DOE 5632 series and the DOE 5633 series of orders. A standardized approach to protection program planning is documented in DOE 5630.11. (See also Section

0283-2, Physical Protection Planning.) This standardized approach provides defense in depth through the integration of physical protection and material control and accountability systems and practices to provide a balanced safeguards and security system. The defense-in-depth concept uses a systems approach that calls for deploying protective forces or features in sufficient strength to constitute more than a single layer of security for a target.

This philosophy for safeguards and security system design should be implemented in accordance with a graded approach for providing protection of Departmental assets. Under the graded safeguards and security approach, a system is to be designed to provide varying degrees of physical protection, material control, and accountability for SNM and SNM facilities. Levels of protection shall be established consistent with the attractiveness of the asset and in such a manner as to minimize inherent risks on a cost-effective basis.

Appropriate levels of protection are determined through a risk evaluation process using vulnerability assessments. Risks to Departmental assess are evaluated in consideration of the degree of protection system effectiveness and the consequent of the loss of a Departmental asset in the event of an adversarial act. The overall goal of the vulnerability assessment is to identify weaknesses that may be exploited by adversaries within the threat spectrum. The threat can include potential sabotage and/or theft perpetrated by either insider or outsider adversaries or a combination of the two working in collusion.

Risk and vulnerability analyses can be used to identify targets that are essential to ensure the operability of safety-class items and the security of critical programs or facilities (i.e., facilities having high value or vital importance to DOE programs as defined in DOE 5480.7). In addition, cost-benefit analyses can be conducted to identify efficient and cost-effective measures to meet site-specific safeguards and security requirements. Targets shall be prioritized so as to determine those to be afforded the greatest level of security in accordance with the graded safeguards and security approach.

The results of these methodologies and analyses are documented in site-specific protection program plans and/or MSSAs. MSSAs are formal agreements between the responsible DOE Headquarters and Field Elements regarding safeguards and security interests to be protected, prescribed levels of protection, accepted risk, and plans to increase protection system effectiveness, if required (see DOE 5630.13).

See also Section 0283, Physical Protection, and Section 0110-13, Physical Protection.

1300-10.2 Physical Protection

1300-10.2.1 General Protection Philosophy

The potential threat of SNM theft requires the adversary to obtain access to the SNM, gather a sufficient quantity for the intended misuse, and leave the facility unhindered to a safe location. Hence, for materials, it may be appropriate to interrupt the adversary anywhere in this chain of events. However, the general approach has been to deny access to very attractive material at all times. In the case of sabotage of a facility, it is necessary to prevent access to certain vital equipment that, if compromised or destroyed, can lead to release of radioactive material or substantial reduction of program productivity. In most DOE facilities, the items of vital equipment have been identified, and protection for these vital areas is required. In most cases, the physical protection systems are similar whether the concern is from theft of SNM or sabotage.

All proposed SNM protection systems and equipment shall be reviewed by safety and health staff personnel to assure that personnel are adequately protected and that the systems do not present an undue risk.

Specific hostile actions to be protected against involving SNM and vital equipment include:

- Theft of SNM, e.g., unauthorized removal from a material access area, protected areas, or an SNM shipment

- Diversion of SNM, e.g., unauthorized placement of SNM within a material access area or protected area

- Sabotage of an SNM facility or vital equipment, including nuclear facilities or shipments, that would result in an unacceptable impact on national security or on the health and safety of the public

- The interruption of programmatic activity that results in an unacceptable impact on national security (which shall be defined by the Head of the Field Element and agreed to by appropriate Headquarters Program Offices)

- The determination of an unacceptable impact on the health and safety of the public based on radiological exposure (which shall be defined by the Head of the Field Element and agreed to by the appropriate Headquarters Program Offices and shall be consistent with Section 0200-1, Facility Siting)

Security areas shall be established to protect SNM and vital equipment as follows:

- A protected area shall be established to control Category I and II quantities of SNM and to provide protection for vital equipment.

- Material access areas shall be established to control access to areas containing Category I quantities of SNM.

- Vital areas shall be established to provide protection for vital equipment.

- Central alarm station access control areas shall be established to protect alarm monitoring and communications capabilities.

The protection afforded SNM shall be graded according to the category of SNM involved. Vital equipment shall be identified by the Field Element and agreed to by the appropriate Headquarters Program Offices.

Nuclear facilities and fuel shall be protected from theft, diversion, and sabotage consistent with the category of SNM involved and the potential impact on national security and the health and safety of the public.

- When nucler facilities contain SNM that is not self-protecting, the SNM shall be protected from theft or diversion at a level consistent with the category of SNM involved.

- When Sabotage of nuclear facilities has the potential to lead to radiological releases in excess of the limits in Section 0200-1, Facility Siting, or to an unacceptable impact on national security, the facilities (including equipment and components essential to prevent sabotage) shall be protected as vital equipment.

- When the sabotage of nuclear facilities does not have credible potential to lead to an unacceptable impact to national security and the health and-safety of the public, the facilities and associated equipment and components shall be protected from sabotage in a manner consistent with the protection needs and acceptable risks as defined by the Head of the Field Element and with concurrence of the applicable Headquarters Program Offices.

Protection strategies for each security interest shall be documented in applicable SSSPs and/ or MSSAs, including appropriate exclusion, containment, and neutralization strategies for the range of hostile activities.

SNM that is classified because of its configuration or content, or that is part of a classified item, shall receive, at a minimum, the physical protection required for the category of SNM involved, or that required for the assigned classification, whichever is greater.

1300-10.2.2 Basic Physical Protection Requirements

The major elements of a physical protection system are the following:

- Detection System: A system providing the capability to detect an adversary action or anomalous behavior (see Section 1300-10.2.5, Detection and Alarm Systems)

- Assessment System: A system providing the capability to assess the nature of the adversary action (see Section 1300-10.2.6, Assessment Systems)

- Communication System: A system providing the capability to communicate to response forces and other personnel (see Section 1300-10.2.7, Communication Systems)

- Barriers: A system of barriers or other impediments to delay, channel personnel, or deny access to SNM or vital areas (see section 1300-10.2.4, Barriers and Access Control Systems)

- Response: The capability of the security organization to neutralize the adversary (see Section 1300-10.2.8, Response Systems)

1300-10.2.3 Baseline Protection Requirements

See Section 0110-13.2, Access Control and Security Areas, for specific security area requirements.

Category I Quantities of SNM

Category I quantities of SNM shall be used, processed, or stored only within material access areas or controlled and alarmed processes enclosed within a protected area.

Category I quantities of SNM shall be stored in SNM vaults equipped with Departmental-approved intrusion alarm systems or in a vault-type room so equipped.

Category I quantities of SNM in use or process shall be under material surveillance procedures in process under alarm protection, or with the approval of the responsible Heads of the Field Elements, protected with alternative means which can be demonstrated to provide equivalent protection.

Category II Quantities of SNM

Category II quantities of SNM shall be used, processed, and stored in a protected area.

Category II quantities of SNM shall be stored in vaults, vault-type rooms, or security containers which are protected with Departmental-approved IASs.

Category II quantities of SNM in use or process shall be under material surveillance procedures, in process under Department-approved alarm protection, or, with the approval of the responsible Head of the Field Element, protected by alternative means which can be demonstrated to provide equivalent protection.

Category III Quantities of SNM

When unattended, Category III quantities of SNM shall be secured within a locked Departmental-approved security container or within a locked room.

When unattended, the container or locked room containing the Category III material shall be under the protection of a Departmental-approved intrusion detection alarm system, or patrolled at intervals not to exceed 2 hours, or located in a protected area.

Category III quantities of SNM shall be used, processed, and stored in a protected area or other security area which has a clearly defined perimeter barrier, personnel and vehicle access control at the entrance, and search procedures.

Category IV Quantities of SNM

Category IV quantities of SNM shall be received, used, processed and stored in accordance with Field Element-approved security plans.

Vltal Equipment

All vital equipment shall be contained within vital areas which are located within protected areas. More than one vital area may be needed within a given protected area.

1300-10.2.4 Barriers and Access Control Systems

See also Section 0110-13.2, Access Control and Security Areas.

An important part of the physical protection system are barriers that impede, delay, or in some cases essentially deny access to SNM in accordance with the DOE 5632 series of orders. Most barriers are passive, designed to require the use of special tools and high explosives to penetrate them. Sophisticated barriers have been tested against a full range of potential adversary tools and tactics. These barriers provide considerable time delay to allow sufficient response-force strength to be assembled to neutralize the adversary force. Specialized barriers have also been developed to delay or stop vehicles, aircraft, and watercraft. Some barriers have been developed that have an active component designed to further frustrate the adversary. These systems may dispense an obscuration agent, a viscous barrier, or a sensory irritant.

In addition to barriers, entry and access portals shall provide equivalent delay to vehicles and personnel. For most protected-area perimeters, electrically operated fence gates shall be considered. Protection shall be provided against vehicle ramming. Techniques used to fulfill these requirements include speed reducing curves, hydraulic bollards, specially designed gates and vehicle traps, and steel cables attached to perimeter fence posts. See Section 1300-10, Physical Protection, Material Safeguards, and Storage of Special Nuclear Material, for specific requirements concerning the construction of vaults and vault-type rooms for the storage of SNM and classified materials.

Protected Areas

Clearly defined physical barriers such as fences, walls, and doors shall be utilized to control, impede, or deny access to protected areas. (See Section 0110-13.3, Physical Barriers, Section 0283-3, Permanent Security Fencing, Section 0283-5.2, Entry Control Points, and Section 0283-5.3, Vehicle Barriers, for more specific requirements). Permanent barriers shall be used to enclose protected areas except during construction or transient activities, when temporary barriers shall be erected. Barriers and other delay systems shall provide assurance that:

- Personnel and vehicles are channeled through designated portals.

- Penetration by motorized vehicles into or out of the security area is deterred and/or prevented where vehicular access would significantly enhance the likelihood that adversaries could successfully steal SNM or sabotage vital equipment.

Adequate spare shall be designed for inspection/search of personnel, hand-carried items, and vehicles as follows:

- Entrance inspections/searches of all personnel and of all vehicles and hand-carried items shall be conducted to provide reasonable assurance that explosives, weapons, or other prohibited articles are not introduced without authorization. Inspection/searchers may be accomplished through the use of X-ray equipment and portal monitors.

- Exit inspection/searches shall be accomplished to prevent the unauthorized removal of SNM at any protected area that contains Category II or greater categories of SNM not within a material access area. All personnel, hand-carried items (e.g., briefcases, lunch pails, handbags) and all vehicles shall be inspected/searched. Personnel inspections/ searches may be accomplished through the use of SNM portal monitors and metal detectors.

- Specific search procedures and SNM/metal detection levels shall be established, justified, and documented in SSSPs and/or MSSAs.

Material Access Areas

Material access areas shall be contained within protected areas. Material access areas shall have clearly defined barriers sufficient to direct the flow of personnel and vehicles through designated portals and allow effective searches by providing reasonable assurance that prohibited articles are not introduced and SNM cannot be transported outside of the material access area without detection.

Adequate space shall be designed for exit inspections/searches of all personnel, vehicles, and hand-carried items, including packages, briefcases, and lunch pails to prevent unauthorized removal of SNM. Personnel inspections/searches may be accomplished through the use of SNM portal monitors and metal detectors.

Specific SNM/metal detection levels shall be established, justified, and documented in SSSPs and/or MSSAs.

Vital Areas

Vital areas shall be contained within protected areas. A vital area shall have a clearly defined perimeter.

1300-10.2.5 Detection and Alarm Systems

See also Section 0110-13.4, Intrusion Detection.

The detection sensor system shall be designed to signal an attempted intrusion, unauthorized attempt at access, or other anomalous situation.

The detection system shall include access-control facilities at each access portal, where the identify of each employee is verified and provision is made for searches of persons and hand-carried packages. Access portals are usually attended by security inspectors and searches are made for contraband or prohibited articles.

On detection of an anomaly, the information shall be displayed on an alarm console or the plant protective force shall be signaled in a way to assist in developing timely and appropriate response measures. (See Section 0110-99.8.7, Security Alarm Control Centers, Section 0110-99.9.4, Alarm Systems, and Section 0110-99.8.5, Radio Control Centers, for additional security alarm control center requirements.)

The following shall be considered in configuring and designing alarm systems:

- Required probability of detection and false alarm rates
- Circuitry to detect tampering with sensors, wiring, or other systems components
- Backup electrical power supplies when site power is lost
- Wiring and system component placement to be contained inside the protected area
- Use of suitable conduit and tamper protected enclosures for alarm wiring
- The ability to test detection sensors weekly

Intrusion detection systems shall be designed as follows:

- A reliable and continuous Departmental-approved IAS sufficient to provide timely detection or intrusion into the protected area shall be provided.
- Rooms, buildings, or portions of a building within a material access area or controlled and alarmed process containing unattended Category I quantities of in-process SNM shall be equipped with Departmental-approved IASs or other equally effective means of detection approved by the responsible Field Element.
- Vital areas containing vita] equipment shall be equipped with a Departmental-approved IAS, or other equally effective means of detection approved by the responsible Field Element.
- Vaults and vault-type rooms used to store Category I or II quantities of SNM shall be protected with a Departmental-approved IAS.

Electronic detection systems shall meet site-specific protection needs and the following requirements:

- All detection/alarm devices shall be connected to monitor/display panels in the hardened central alarm station (and protective force communications center).
- An alternative alarm annunciation point to the central alarm station (or a comparable alternative capability) shall be provided in a location that is continuously manned by personnel and which provides a second indication of an alarm such that a response can be initiated in the event the primary station is compromised.
- When used, devices and equipment for interior IDSs required for storage of SNM shall meet FS W-A-450B or be approved by the Field Element.
- Exterior sensors that serve as the primary means of detection at a security area perimeter shall be designed to provide assurance that a person crossing the perimeter will be detected whether walking, running, jumping, crawling, rolling, or climbing the fence at any point in the detection zone.
- All detection/alarm devices, including transmission lines to annunciators, shall be failure- and tamper-indicating in both the access and secure modes.
- Alarm lines shall be continuously supervised so as to detect any attempts to short, open, or substitute a bogus signal for the legitimate “no alarm” signal in a surreptitious attempt to bypass the alarms system.
- IASs shall have both a primary and an auxiliary power source. Switchover to the auxiliary power source shall be automatic upon failure of the primary power source. An alarm condition shall be indicated at the monitor on failure of all power sources.

The protection program shall include means to assess alarms and activities of adversaries promptly, accurately and reliably.

1300-10.2.6 Assessment Systems

On receipt of an alarm or detection of an intrusion, the nature of the threat can be assessed to initiate an appropriate response. Generally, the assessment is done visually by dispatching a security inspector. In the more critical facilities, rapid assessment shall be accomplished by the use of CCTV systems where the monitor is located in the central alarm station.

1300-10.2.7 Communication Systems

See also Section 0110-13.5, Communications Equipment.

Following assessment of the nature of the threat, the intrusion shall be communicated to response forces. Communications between the CAS and the response force security inspectors are generally by two-way radio, telephone, or other signaling system. Communication to local law enforcement agencies is by telephone or radio. Special response teams shall be equipped with voice privacy or digital equipment two-way radio operation.

The CAS and SAS shall be designed with substantial walls, ceilings and floors to provide protection for security personnel and communications equipment.

All communications systems shall be tested at the required frequency to assure readiness.

Security inspectors at fixed posts shall have both normal telephone services and two-way communications with CASs, and with alternate positions from which backup forces will be dispatched.

Security inspector at mobile and fried posts shall be provided with duress systems. This requirement may be met with hand-held radios equipped with a duress feature.

A hardened CAS (and protective force communications center) shall be equipped with radio and telephone channels of communication with local law enforcement agencies. An emergency alternate communications capability from a secondary station shall be provided for use in the event the primary station is compromised. Radio communications equipment shall remain operable in the event of a loss of primary electric power.

Communications equipment shall allow rapid, reliable, and protected information exchange between on-site protective forces; between on-site protective forces and the CASs and secondary communications station; and between the CASs, secondary communications stations, and local law enforcement agencies.

1300-10.2.8 Response Systems

The primary and first response to an overt intrusion or attempt at SNM theft or sabotage shall be by facility security force. The security force also conducts access control checks and searches, patrols security areas, maintains liaison with local law enforcement agencies, checks barriers and other security hardware, and provides limited law enforcement and traffic control services. Its primary mission, however, is to prevent the theft of SNM or the sabotage of facilities.

To support the facility security force, provisions shall be designed for security inspector posts at access portals, fixed and mobile defensive positions, and guard towers. The need and location for these shall be determined on a facility-specific basis in consideration of the DOE 5632 series of orders, the Departmental threat guidance, and the nature of the materials and facilities being protected.

Security inspector posts, both mobile and fixed, for protected areas shall be equipped with duress systems and be designed and located in accordance with applicable requirements contained in DOE orders. Security inspector posts shall be located to provide an unobstructed view of the surrounding terrain. The exterior walls, windows, and doors shall be constructed of reinforced materials which have a bullet penetration resistance equivalent to “high-powered rifle rating” as given in UL 752.

Whenever practial, containers for the storage of weapons and ammunition shall be GSA-approved weapons storage containers which are bolted or otherwise secured to the structure.

For guard towers that are intended to serve as fighting positions and emergency defensive positions for security inspectors, consideration shall be given to protected firing posts and provide a minimum of 60 square feet of floor area per person. (See Section 0283-6.2, Guard Towers.)

1300-10.2.9 Lighting Systems

See also Section 0283-7, Lighting.

Adequate illumination may also assist in detection of adversaries as well as assessing the nature of previously detected intrusions. When properly designed, security lighting also provides a deterrent. Where required, lighting systems shall have a backup electrical power system to minimize the interruption of illumination in case of a loss of site power.

1300-10.3 Material Control and Accountability (MC&4) Safeguards

1300-10.3.1 General

The objective of domestic safeguards is to protect sensitive nuclear materials from theft or diversion and the material or facilities from sabotage. MC&A safeguards activities are concerned with malevolent activities that might be undertaken by authorized personnel (insiders), although such activities overlap with those carried out for the purposes of physical protection.

The major objective of the MC&A system is to provide the capability to detect, deter, and assist in the prevention of unauthorized use or removal of SNM from the facility or its authorized location, in a graded approach; that is, in a manner appropriate to the types and quantities of material at risk and as appropriate to the threat involved. DOE 5633.3 defines the basic requirements for MC&A at DOE facilities. Also relevant are DOE 5633.2 and DOE 5633.4.

The systems used to carry out the MC&A safeguards function can be divided into the categories of material accounting, material control, personnel control, and process/ monitoring/near-real-time accounting. The emphasis that is placed on these different aspects of MC&A shall differ depending on the nature of the facility and the safeguards approach adopted for the facility as specified in site MSSA and SSSP documents Provisions shall be considered very early in the design, and continuously evaluated through the various design stages to ensure that all requirements are met. The design team should include personnel with extensive knowledge of MC&A requirements. The design management process shall provide adequate review and integration of the concerns of the cognizant DOE Safeguards and Security Coordinator(s) throughout the course of design.

1300-10.3.2 Material Control Systems

Material control systems shall alert the facility to unauthorized activities. Physical barriers should be employed for containment of materials. Detection should be implemented using a variety of surveillance and monitoring techniques.

A number of boundaries shall be considered to control the movement of material:

- The boundary defined by the surface of the process equipment
- The boundary defined by the walls of rooms containing process equipment
- The boundary of the "material access area" as defined in DOE 5633.3
- The boundary of the protected area as described in physical protection orders
- The boundary defined by specially constructed areas such as storage vaults

The reliance placed on each of these boundaries to prevent or detect the theft or diversion of material will depend on the safeguards strategy of the facility involved; however, the material access area boundary and the integrity of vaults shall generally be the most important in terms of design.

Material Access Area (MAA) Boundary

The objective of the MAA boundary is to prevent or detect the unauthorized movement of material through it, while allowing for authorized personnel access, authorized material movement, and emergency evacuation as necessary. This means that designed-in penetrations of the MAA boundary shall either be monitored, or not present a credible path for material removal, and that malevolent penetration of the MAA boundary is either not credible or is detectable.

- Walls defining the MAA boundary shall be designed/constructed so that penetration within the specified delay times is not credible. Some type of monitoring shall be provided where penetration is credible. Designs in which the walls are easily penetrated are hidden from view are not advisable. MAA walls shall not provide hiding places or redoubt-like structures for adversaries.

- Penetrations in the floor and ceiling for piping, heating, venting, and air conditioning, and other support systems shall not be large enough or accessible enough to create credible paths for the removal of material. As with wails, ceilings should not provide places to hide material.

- Portal systems shall allow for the passage of personnel while detecting the presence of nuclear material and metal. (While material control and accountability concerns generally relate to insiders bringing material out, physical security concerns at portals include the detection of explosives or weapons.) Sometimes, in addition, equipment/package portals are used so that tools and packages can be monitored separately. The following should apply to the design of portals:

- Special nuclear material portal monitors should be distanced from or shielded from nuclear materials in the process area. This applies not only to locations of static storage, but to passageways or conveyer systems that allow the passage of materials within the facility.

- Portal monitors shall be located so that it is not physically possible to pass items around the portal without those objects' undergoing some sort of surveillance (e.g., passing through the guard station).

- Portal monitors are generally co-located with guards stations, so that an adequate response to an alarm is available. Unattended portals require careful design to assure response to and resolution of alarms. The guard stations serve to control the flow of personnel into the area via I.D. badges, etc. When this is the case, the guard station should provide an unobstructed view of the portal. Electronic communication between the guard/station and the central security station shall enable the monitoring of power, alarms, etc. Guard stations shall be designed using physical security design criteria as well.

- In processing areas, provisions shall be made for planned and emergency evacuations. Where this evacuation occurs through the MAA boundary, alarmed doors shall be provided, as it is too expensive (and probably not operationally sound) to try to use personnel portal monitors. In such cases, provision shall be made to assure that evacuations do not provide a theft opportunity. One strategy is to provide a fenced evacuation zone outside the alarmed door. This evacuation area is placed under surveillance by the guard force during evacuation conditions and swept with SNM detectors afterward to make sure no material has been left behind. Effective use of the SNM detectors requires that these areas be not too large and that they have low background radiation levels.

- Nuclear material shall be transferred into and out of the MAA at well-defined locations (usually loading docks) subject to specific procedures that prevent unauthorized transfers. Transfer operations are simplified if the transporting vehicle can discharge directly into the MAA. Such transfer locations shall involve alarmed doors and communications capability with the central guard station. NDA capability at the site shall be considered for verification or confirmation of the shipment or receipt. Health physics measurements may also be involved in the processing of the receipt.

Depending on the types of materials to be received, more elaborate procedures or capabilities such as sampling shall be considered.

Storage Areas and Vaults

Material awaiting processing shall be stored in a graded system with appropriate access controls. Facilities shall be designed to minimize the amount of attractive material located in accessible locations for long periods of time. Recent vault design has emphasized automation as this limits hands-on access to materials and provides automatic documentation of material movements. Vaults containing attractive material should prevent hands-on access to material and should provide hookup to central station and appropriate lockouts. Other strategies (such as locked carts) are used for short-term storage of less attractive material.

Physical relationships should be considered in determining locations of vaults, processing areas, shipping/receiving areas and NDA stations as materials will flow from one of these to the other.

Containment of Material in Process Equipment and Material Transfer Systems

Process equipment often provides a natural barrier to the acquisition of material. To the extent that this function can be enhanced it can play a supplementing or compensating role to other material containment strategies. Thus if there is no need to have direct access to material in a process or transport step, access can be denied using appropriate physical barriers. If areas where materials need to be accessed (e.g., loadout areas) are few, strategies such as two-person rules or two-person interlocks shall be considered for attractive materials.

Surveillance Systems

Electronic surveillance systems (CCTV) shall be considered for use in sensitive areas such as loadout stations and transfer locations. Adequate lighting and field-of-view are two of the operating design criteria in such locations. Areas where an individual could work unobserved shall be minimized.

Tamper Indicating Devices (TIDs)

The design of MAA exit doors, vault doors, vault racks, containers, etc., should provide for seal (TIDs) mechanisms. Requirements for use of TIDs are contained in DOE 5633.3. DOE/EP/0035 should be considered.

The design of the facility shall accommodate procedures that address abnormal situations. Mechanisms shall be provided to prevent uncontrolled egress or SNM removal from the protected area should a crash out (broken TID and Alarm) from an MAA occur.

Protected Area (PA) Boundary

The PA boundary is generally viewed in terms of outsider attack; it may also be designed to prevent material from being removed by an insider. In this case, design shall allow for appropriate personnel and vehicle portals. The fence system shall he designed so that material cannot be thrown over it for later retrieval. Proximity to buildings or other overhanging structures shall be considered.

1300-10.3.3 Material Accounting Systems

Material accounting systems track nuclear material items through the facility and provide quantitative data on material flows and inventories throughout the facility. Facilities are subdivided into MBAs; on a regular basis the flows of nuclear materials into and out of these MBAs are compared with the measured nuclear material inventories to establish that material has not been removed from the system.

Difficult-to-measure materials pose problems for accountability systems. One category of difficult-to-measure materials is holdup, which is addressed below. Other such categories are scrap and waste. Such materials should not be allowed to accumulate. Scrap-recovery facilities should be sized to enable timely recovery of materials. Similarly, waste-measurement facilities should be adequately sized.

MBA Boundary Definition

The purpose of subdividing the facility into MBAs is to enable the facility to localize losses to a particular process step or steps. MBAs are generally defined around specific processes (e.g., casting, recovery) and therefore cover a specific geographical area. DOE orders specify that MBA boundaries do not cross MAA boundaries. An important criterion for defining MBA boundaries, however, is that material entering or leaving the MBA should do so on measured values. Sometimes these goals may conflict; for example, small amounts of material may exit the MAA in vents to be caught in filters. These filters shall be considered to be within the MBA for the sake of maintaining good MBA accountability, even though the boundary-crossing rule is technically violated. MBA boundaries may be conceptual but are fundamentally physical. Materials often move physically out of the geographical MBA boundary before they are measured, although they are still conceptually considered to be in the MBA.

However, the location of MBA boundaries do imply measurement requirements, and this shall be considered in facility design. If the measurement is by NDA, the material will have to be brought to the NDA equipment or vice versa. If the measurement is destructive, similar considerations apply to sampling capability.

Measurement Systems

Measurement systems shall be either installed in the process equipment, located in the process area, or located in an entirely separate laboratory area. Small weighing systems, volume measurement systems, and some NDA equipment are generally installed in the process equipment itself. Other NDA equipment (such as calorimeters) are generally installed within the MAA. Destructive chemistry, mass spectroscopy, etc., are carried out in separate laboratories.

- Weighing systems should be installed in areas that are free from mechanical vibration. Adequate space should be allocated for weight standards.

- In vessels holding solutions containing special nuclear material at inventory, volume measurement and sampling capability are necessary to establish the contents of the tank. The following shall be considered in designing such systems:

  – The capability should be available to mix the tank to a state of homogeneity. This can be accoplished by mechanical mixing or sparging techniques. Considerations of criticality safety and mixing are often in conflict. Some tanks are extremely difficult to homogenize. Slab tanks may need more than one agitation device to provide for adequate mixing.

- The sampling systems used should not dilute or concentrate the sample they are generating. Recirculating samplers are used to make sure samples are representative and not biased by previously drawn samples. In systems that will lift liquid streams in recirculating samplers by injecting air into the upflow side, the possibility exists that evaporation will occur, especially if circulation is for some reason slowed.

- Plugging of sampling lines can cause problems at some facilities; procedures and designs should be in place to prevent this.

- Provisions shall be made for removal and transportation of the sample.

- Tank geometry also contributes to the ability to measure volumes accurately. Tanks oriented horizontally are very difficult to measure.

- Liquid-level measurements in tanks are generally established by either sight glasses, capacitance probes, or bubbler systems (whose back-pressure is measured in a variety of ways). Bubbler-probe systems are generally the most accurate, but provision has to be made for connection to the plant air supply. Tanks containing nuclear material at the time of an inventory or tanks used to establish the input or output values for an MBA shall be recalibrated regularly.

- Large heels in tanks should be avoided.

- NDA techniques at nuclear processing facilities generally involve radiation measurement (active or passive) or calorimetry. Facility design shall provide such instrumentation with a suitable environment as follows:

  - Specialized NDA instruments sometimes require friendly environments in terms of temperature, humidity and vibration Specifications set down by the instrument manufacturer shall be consulted. It may be necessary to isolate the instrument against electromagnetic interference. High-resolution gamma ray systems will need to be supplied with liquid nitrogen.

  - Background radiation levels (both static and transitory spikes caused by movement of material) shall be considered in choosing the location of all radiation-sensing equipment.

  - The location of the NDA station should take into account the need to transport materials to the station from the process, and the health/safety impacts of such movement. Certain types of measurements may be impractical if materials have to be repackaged simply to measure them.

Holdup

In broad terms, holdup is nuclear material that is retained in process equipment at inventory time. Poor accountancy results when the amount of holdup is large and uncertain. Holdup can be either eliminated, measured, or modeled to improve accountant, but the design goal shall be to minimize nuclear material holdup. For example:

- Minimize the use of horizontal piping runs for high concentration solutions, and allow enough slope for the pipe to drain.
- Eliminate piping configurations where material can collect, especially dead-end piping.
- Design equipment for easy cleanout; this applies especially to gloveboxes and incinerators. Minimize sharp angles and hard-to-access corners where material can collect. Provide adequate lighting.
- Where material cannot be cleaned out, but potential exists for significant holdup, designed-in NDA measurement capabilities shall be considered. It is often important to experiment with the response of these instruments and establish calibration data before the process goes hot.

Data Acquisition/Data Processing Systems

Material accounting systems generally require a mainframe computer and remote data-entry stations in the process area. Data may be acquired directly from in-line instruments. The design of such data acquisition systems is beyond the scope of this document. However, the spatial and environmental requirements for operation of data-entry terminals shall be considered. In many cases the data involved will be classified, and appropriate orders and guidance on the characteristics of classified data processing equipment consulted (see DOE 5637.1).

1300-10.3.4 Other Systems

Process Monitoring/Near-Real-Time Accountancy (NRTA)

Process monitoring systems collect data on process variables (liquid levels, densities, valve positions) and perform consistency checks that may reveal anomalies if material is diverted or if other important procedures are not being followed (for example, if a tank is not sampled before transfer, or not sparged before it is sampled). Processes involving large tanks can be instrumented in this manner relatively easily, resulting in an additional detection mechanism as well as better (more reliable) accountability measurements. Such instrumentation shall be considered.

Because of the need for frequent computation of material balances, NDA instrumentation shall be provided.

Personnel Control

Personnel access to various parts of a facility (and materials within the facility) are often controlled at a finer level than the MAA; to accomplish this, it is necessary to subdivide the MAA into rooms or sets of rooms to which access is granted by electronic card systems, keypads, guard stations, or other devices. This reduces the number of people having access to a wide range of materials.

1300-11 DECONTAMINATION AND DECOMMISSIONING

1300-11.1 Decontamination

Design of the areas in a facility that may become contaminated with radioactive or other hazardous materials under normal or abnormal operating conditions shall incorporate measures to simplify future decontamination. Such items as service piping, conduits, and ductwork shall be kept to a minimum in these areas and shall be arranged to facilitate decontamination. Filters shall be positioned in ventilation systems in locations that minimize contamination of ductwork. Walls, ceilings, and floors shall be finished with washable or strippable coverings. In some areas, metal liners shall be required. If necessary all cracks, crevices, and joints shall be caulked or sealed and finished smooth to prevent contaminated material accumulation in inaccessible areas. Finishes shall comply with Section 0900-99, Special Facilities.

1300-11.2 Decommissioning

Designs consistent with the program requirements of DOE 5820.2A shall be developed during the planning and design phases based on a proposed decommissioning method or a conversion method leading to other uses.

Decommissioning of special facilities is of utmost importance. The facility design shall include features that will facilitate decontamination for future decommissioning, increase the potential for other uses, or both. In addition to the requirements of Section 0205, Demolition, Decontamination, and Decommissioning, the following design principles shall be considered for facilities handling radioactive and other hazardous materials:

- Use of modular, separable confinements for radioactive and other hazardous materials to preclude contamination of fixed portions of the structure

- Use of localized liquid transfer systems that avoid long runs of buried contaminated piping; emphasis on localized batch solidification of liquid waste. Special provisions should be included in the design to ensure the integrity of joints in buried pipelines.

- Location of exhaust filtration components of the ventilation systems at or near individual enclosures so as to minimize long runs of internality contaminated ductwork

- Equipment, including effluent decontamination equipment, that precludes, to the extent practicable, the accumulation of radioactive or other hazardous materials in relatively inaccessible areas including curves and turns in piping and ductwork. Accessible, removable inspection covers are encouraged to allow visual inspection.

- Materials that reduce the amount of radioactive and other hazardous materials requiring disposal and that are easily decontaminated

- Designs that ease cut-up, dismantlement, removal and packaging of contaminated equipment from the facility (e.g., removal and dismantlement of gloveboxes, air filtration equipment, large tanks, vessels, equipment and ductwork)

- Use of modular radiation shielding, in lieu of or in addition to monolithic shielding walls

- Use of lifting lugs on large tanks and equipment

- Fully drainable piping systems that carry contaminated or potentially contaminated liquids

1300-12 HUMAN FACTORS ENGINEERING

1300-12.1 Coverage

It is DOE policy to ensure that appropriate human factors technology is considered in the design, operation, and maintenance of Departmental nonreactor nuclear facilities. The criteria and requirements provided in this section are applicable to the design of the work environment and human-machine systems at DOE facilities. These criteria shall apply to new construction and to retrofitting of existing facilities. These criteria shall be considered for upgrading existing facilities where cost-benefit or risk-tradeoff analyses indicate justification for such expenditures.

This section outlines a general criteria for incorporating human factors engineering into the system design process. In addition, it provides human factors engineering considerations for system and component displays, controls, alarms, labeling, and communications that are generally applicable to a wide range of human-machine systems, and for the work environment for personnel, including such matters as ventilation, lighting, noise control, work space layout, and equipment design and layout.

1300-12.2 Objectives

The primary objective of human factors engineering is to improve human performance through enhancements in the work environment and human-machine interfaces. To achieve this objective, human factors engineering consideration shall be included during the conceptual, preliminary, and design phases of a project.

Enhancements to the work environment and human-machine interfaces will reduce human error and its consequences and lead to increased productivity, lower costs, etter product quality, decreased equipment and property damage, improved program schedules, personal job satisfaction, and, perhaps more important, to further improvements in the safe operation and maintenance of DOE facilities.

1300-12.3 System Development

1300-12.3.1 General

The integration of human factors engineering into system development shall begin at the point when the detailed system goals and objectives have been defined. This integration into the system development process shall proceed through four phases: planning, requirements analysis, system design, and system test and evaluation.

Throughout this process, it is important to provide a mechanism that incorporates the knowledge and input of the personnel who have used or will be using the types of equipment, systems, or facilities being designed. Their input shall be systematically developed and applied from the beginning of the requirements analysis phase.

1300-12.3.2 Planning the Human Factors Engineering Role in System Development

A human factors engineering program plan appropriate to the level of importance of a facility or system shall be developed during the system development process (i.e., as an integral part of the conceptual design phase). The plan shall detail the kinds of human factors engineering analyses and evaluations necessary for the design and shall reflect the integration of the human factors engineering effort with the other disciplines having design input. The information inputs include a description of system objectives, applicable standards and specifications, and other project-specific information.

1300-12.3.3 Requirements Analyses

A systems requirements analysis appropriate to the level of importance of the system and the level of risk associated with system failure shall be performed as an integral part of the design process and shall include human factors engineering considerations.

The needs and requirements of the system user or operator shall be systematically examined as an integral part of the design process. Appropriate requirements shall be selected and analyses performed for systems that are important to safety to ensure that the public, the facility, and facility personnel risks are minimized. These analyses shall be directed primarily to the areas of human-machine function allocation and task analysis. A variety of human factors engineering analysis techniques are discussed in NUREG CR-3331 and Meister and Rabideau, Human Factors Evaluation in System Development.

Decisions concerning which system functions to allocate to the human versus the machine shall be determined by analyses of system functions required, impact of error or no action on safety, and a comparison of human capabilities and equipment capabilities for the separate system functions. Factors that shall be considered during the function allocation decision process include system performance criteria, safety, cost, maintainability, scheduling, and training.

For functions allocated 10 an operator, there shall be a systematic analysis of those vital activity tasks that must be performed by the operator to satisfactorily complete the function.

given a proposed system design. This task analysis shall develop a list of operator needs and requirements necessary for successful task completion. The list shall include not only information and control requirements, but also the number and types of staff required by the various functions, knowledge requirements and special skills, operator aids, decisions to be made by the operator, communication requirements, necessary operator interactions, and any potential safety hazards.

In the development of operator requirements, task conditions associated with high work load features, concurrent emergency conditions and those tasks that must be performed concurrently, to a high degree of accuracy, without error, in short time periods, and/or with a high degree of skill shall be considered for proper function allocation.

1300-12.3.4 Process System Design Interfaces

The design or the selection of equipment to be operated and maintained by personnel shall include the application of human factors engineering criteria together with other appropriate design criteria.

These criteria shall include the list of information and control requirements developed from the task analysis. More generic human factors engineering criteria pertaining to desirable equipment characteristics, available in the form of checklists or text descriptions, shall also be consulted. Studies performed to examine special features of the system design shall be considered.

Human factors engineering data, requirements, or other input to be incorporated into the design shall be made available at the very beginning of the design process. Human factors engineering input to the system design process shall be presented as specific and quantitative design requirements where possible.

The system design process consists of numerous decision points at which choices between options and alternatives are necessary. To the extent possible, these decision points shall be anticipated and the appropriate human factors engineering criteria shall be made available, particularly where safety factors or other important functional features are involved.

As the design evolves from the preliminary concept through the detailed states, there will be modifications in earlier basic decisions and assumptions made by the design team. Human factors engineering requirements shall be refined and design recommendations made more specific during the system design evolution.

Design teams and design review teams shall include or have resource support available from persons knowledgeable in human factors engineering. Human factors personnel shall also be included in the system validation process.

1300-12.3.5 Test and Evaluation

The test and evaluation phase shall focus on verifying that the system can be operated and maintained by the intended user personnel under the conditions for which it was designed. The system shall meet applicable human factors engineering design criteria.

Human factors engineering evaluation and testing shall preferably begin early during the design development and shall be a continuing activity throughout design and construction.

Tests shall be planned to observe the system in simulation or in actual use based on normal and abnormal procedures and scenarios.

Any findings from these tests and evaluations shall be incorporated into the system design and into a final testing phase after completion of system development. Discrepancies between desired and observed system performance shall be documented together with proposed corrections.

1300-12.4 General Human Factors Implementation Criteria and Considerations

1300-12.4.1 General

This section provides generic human factors engineering considerations. Facility- or system-specific human factors engineering requirements shall be generated through the requirements analysis discussed in Section 1300-12.3, System Development. The generic considerations in this section shall be combined with the requirements analysis results to ensure that all appropriate human factors considerations have been identified and addressed.

Human factors engineering principles and criteria shall be integrated into the design of systems and the facilities that house and support these systems.

The organization of operator movements and the arrangement and accessibility of equipment and controls in the work area shall facilitate convenient access to each system component for operation and maintenance.

1300-12.4.2 Human Dimension Considerations

Equipment that is to be used by personnel shall be designed or selected to accommodate their body dimensions. This equipment includes control panels, work tables and counters, enclosures, seating, storage, special clothing, and any other equipment designed for an operator. The design of equipment for personnel shall accommodate a wide variety of body dimensions. Generally, it is recommended that equipment dimensions accommodate the fifth to ninety-fifth percentile of the user population. For recommended data representing these percentiles (from military studies), see NUREG 0700, Section 6.1, and MIL-STD-1472C, Section 5.6. These references also provide recommended dimensions and other guidance for stand-up and sit-down consoles and other work stations, for accessibility of equipment and instrumentation, for furniture and equipment layout, and for traffic flow.

1300-12.4.3 Environmental Considerations

Temperature and Humidity

An effective climate control system shall maintain temperature and humidity at an acceptable level between the human and the environment. Temperature and humidity tolerance limits for recommended comfort zones are provided in NUREG 0700, Section 6.1, and UCRL 15673, Section 3.2.4.5.

Ventilation

See Section 1550-1.5, Ventilation-Exhaust Systems Design Requirements.

Lighting

Adequate light levels are necessary to ensure optimum performance in all work areas. Glare and shadowing shall be avoided. For recommended control room illumination levels, luminance ratios, reflectance levels and further lighting considerations, see Section 1655, Interior Lighting, and NUREG 0700, Section 6.1.

Lighting design shall consider environmental degradation effects (such as dust or radiation on viewing ports) to ensure adequate lighting intensities can be provided on a long-term basis.

Emergency Lighting

Emergency lighting systems shall be provided as required by NFPA 101. A control room emergency lighting system shall be automatically activated and immediately available for a stated minimum length of time on failure of the normal lighting system. The emergency lighting system for vital areas shall be an electrically independent system that is not degraded by failure of the normal lighting system. Control room emergency lighting levels shall be in accordance with NUREG 0700, Section 6.1.5.4.

Noise

Acoustic design shall:

- Minimize noise levels where practical and ensure that the limits of DOE 5480.10 are not exceeded
- Ensure that verbal communications are not impaired
- Ensure that auditory signals are readily detectable
- Minimize auditory distraction and irritation that can cause operator fatigue

For further noise level and protection considerations, see NUREG 0700, Section 6, and UCRL 15673, Section 3.2.4.2

Vibration

Vibration shall be reduced to the extent practical to minimize operator irritation and distraction. Vibration considerations shall include equipment and tool design, potential effects of vertical and horizontal vibrations on seated and standing operators, and use of appropriate protective devices (e.g., isolation, damping materials). For recommended vibration level limits and further considerations see UCRL 15673, Section 3.2.4.3.

Aesthetes

Cosmetic and aesthetic design considerations shall be reviewed for Compatibility with the work area.

1300-12.4.4 Component Arrangement

The arrangement of controls and displays on a control panel shall promote efficient use of task-related components, rapid location of any given component, and maximum operator awareness of plant conditions. EPRI NP-3659, Chapter 4, and NUREG 0700, Sections 6.8 and 6.9, discuss these concers and related items.

Components shall be grouped together on the basis of specific criteria appropriate for the required task or tasks. Useful grouping alternatives to be considered include grouping by system membership, which allows subgrouping and mimic methods, and grouping by task relationships such as sequence of use or frequency of use. The groupings shall be emphasized and defined by consistently applied graphic-spatial methods such as demarcation and spacing of components, particularly when there are many components.

Components shall not be hidden within component groupings. Unbroken strings of similar components on the panel shall be avoided. Matrices of components shall have labeled axes to identify any component in the grid. Recurring component subsystems (e.g., Loop A, Loop B,.. .) shall each be arranged as consistently as possible. Mirror image arrangements of components shall be avoided.

Component arrangement shall promote easy association of related controls and displays or other related components. Displays are usually placed above and relatively close to the related control.

Component arrangement conventions shall also be considered, particularly when mimic displays are not used. For instance, when several components related by flow direction (e.g., valve-pump-valve) are placed in sequence, the direction of the sequence (e.g., top-to-bottom, left-to-right) shall be consistent for each similar situation.

1300-12.4.5 Protective Equipment

Personnel who work in a hazardous environment (e.g., an environment subject to radiation, gas, airborne particles) or who may be temporarily-exposed to such hazards shall have convenient access to the appropriate protective equipment including proper garments, equipment such as emergency showers and eyewashes, and any other protective equipment necessary for the successful and safe completion of their work.

Provisions shall be made for access and maintenance of protective equipment. Protective equipment shall be periodically checked and shall be maintained in good condition. Storage spaces shall be provided and shall be easily accessible to required personnel.

Personal protection equipment such as garments and breathing apparatus shall be compatible with the body sizes of personnel performing their tasks. There shall be sufficient quantity of this equipment in the proper sizes for the required number of users. Equipment and garments of different sizes shall have permanent size labels located where they are easy to read. There shall be provisions for an adequate supply of personal protective equipment expendables, such as filters, that are stored with the related protective equipment. Guidance is presented in NUREG 0700, Section 6.1.4.

The design or selection of protective equipment shall be such that it minimizes the impairment of operational and maintenance performance. It shall provide adequate tactile sensitivity and provide the ability to see, reach, move, communicate, and hear. Other considerations include operability and accessibility of equipment by users of protective equipment, provision of an adequate level of safety for the user, and user comfort while working.

1300-12.4.6 Display Devices

Operator task analysis results shall be the basis for establishing operator information needs. Displays shall provide only the information about system status and parameter values that is needed to meet task requirements in normal, abnormal and emergency situations. Status, rather than demand information, shall be displayed for important parameters. Displays shall indicate whether they reflect demand or actual status.

Each display device, including meters, CRTs, LCDs, consoles, and other electronic or mechanical media shall be formatted and designed to ensure that both the display and display content are readable, understandable, and accessible.

Variables important to the adequacy of displays include letter size, font, contrast, viewing distance and angle, lighting, color, and complexity of the task. For additional information see NUREG 0700, Section 6.5, and MIL-STD-1472C, Section 5.2.

Failure of a display of any type shall be easily recognized and shall not affect equipment or system performance.

Where CRTs are used, rapid, error-free access to the information required for the task shall be accomplished by ensuring that system response to any query is less than 2 seconds and that user feedback to control action is less than 0.2 seconds or faster wherever possible. More specific information is contained in NUREG CR-2496. The use of CRT displays also allows removing hardwired displays except those that are essential for various backup functions. Analyses shall be performed to determine where hardwired displays are required and where those displays shall be located relative to the corresponding controls and to CRT displays.

1300-12.4.7 System Controls

The equipment used by an operator to control a complex system is often a composite of many systems. A control panel operator shall be able to rapidly locate each component on a panel. To achieve this, the design shall take full advantage of several techniques of control display integration including various component grouping techniques, system mimics, system demarcation, and hierarchical labeling.

Spurious or ancillary information and data may contribute to operator information overload. Prioritized coding, organization of data by system and subsystem, demarcation of system and subsystem components, and removal or relocation of marginally useful data shall be used to reduce operator information overload. For additional information, see EPRI NP 3659, Chapter 4; NUREG 0700, Sections 6.1, 6.3, 6.7, and 6.9; and Van Cott and Kincade, Human Engineering Guide to Equipment Design, Chapter 9.

Component Controls

Each control device shall provide the appropriate control capability, range, and sensitivity for necessary control settings and manipulations. Control operating characteristics shall conform with operator expectations. Control components shall be durable, compatible with nontypical apparel where required, and not prone to accidental activation.

Selection of a control device shall fulfill any control requirements described in the task analysis of system functions. In addition, selection shall consider whether a discrete or continuous function is present, and the compatibility relationship between the control and any corresponding displays, the ease with which the function of the control can be identified, the ease of identifying the control actuation mode provided by the control (e.g., on, off, auto), the force necessary to activate the control, and the tactile feedback provided by control actuation.

Selection of controls shall consider the use of coding methods. Coding methods include location, size, shape, and color. For coding guidelines, see NUREG 0700, Section 6.4.

Specific criteria shall be applied to various types of common controls such as rotary controls, toggle switches, push buttons, rocker switches, and linear switches. NUREG 0700, Section 6.4; MIL-STD-1472C, Section 5.4; and Van Cott and Kincade, Chapter 8 describe these criteria. The latter reference also discusses conditions requiring unconventional controls.

1300-12.4.8 Warning and Annunciator Systems

An effective warning system shall alert personnel to a problem or abnormal condition and shall provide sufficient time to respond appropriately to the problem. General warning guidelines are found in MIL-STD-1472C, Section 5.3. For the special case of control room annunciators, see NUREG 0700, Section 6.3. For auditory signals guidelines, see NUREG 0700, Section 6.2

To provide an effective alerting stimulus, it is first necessary to determine whether both auditory and visual stimuli shall be used or just one. Guidelines for determining stimulus modality are provided in Van Cott and Kincade, Chapter 4. For instance, a visual signal shall be used if the message is complex, long, or has to be referred to later. An auditory stimulus is usually provided for warnings requiring rapid response, especially with a mobile operator in an information-rich environment.

Each stimulus shall be easily distinguishable from other stimuli in the same modality but it shall not be a distraction. If an alarm can be one of many similar alarms that may occur simultaneously, it shall be easy to locate.

Any specific stimulus shall have only one meaning. It can either designate one problem or it can be a signal to look at a particular place to define the alarm further. When there are many annunciator alarms, priority coding such as “first in/out” shall be used to assist in determining message significance, False alarms and nuisance alarms shall be removed. Set point determination shall allow sufficient response time to the operator.

Provision shall be made for active acknowledgment and for silencing of auditory alarms after they have been acknowledged.

Provision shall be made for maintaining personnel awareness of alarm conditions until they have been corrected or "cleared." Clearing of the alarm shall require a positive response from the assigned personnel.

Visual alarm tiles shall be grouped by function or system within panels having horizontal and vertical alphanumeric labeling for ready coordinate designation of individual tiles. Legends shall be unambiguous and address specific conditions. Viewing distance to operator, legend contrast, type style, and letter dimension and spacing shall be considered.

It shall be possible to test the warning system periodically.

1300-12.4.9 Communication Systems

A communication system shall allow the users to transmit and receive information accurately and conveniently with minimum distraction from the user's other tasks. A user requirements analysis shall be performed to determine which of the various types of communication systems is most appropriate for the user conditions and what characteristics the selected system shall have.

Factors to be addressed in the requirements analysis shall include the number of intended recipients, the need for private conversations, mode of information transmittal (e.g., visual, aural, tactile), locations and levels of noise or other interference, and the necessity for recording the message. Any special needs of the users (e.g., necessity to keep the hands free, inability to be at a constant location, classification of data) shall be considered.

General criteria that shall be satisfied by most auditory systems include a minimum frequency response, feedback, sufficient dynamic range and gain to handle instantaneous pressures characteristic of speech, and sufficient speech intelligibility. The system shall have provisions for periodic maintenance tests, instructions for the use of each system used, and procedures for handling emergency communications where applicable.

Specific criteria shall be applied to each type of communications system. For instance, public announcing systems shall have carefully planned Loudspeaker locations to eliminate dead spots. Headsets for sound-powered telephones shall leave the hands free. Switching mechanisms in conventional telephones shall minimize delay in making connections. These criteria are discussed extensively in MIL-STD-1472C; Van Cott and Kincade, Chapter 5; and NUREG 0700, Section 6.2.

1300-12.4.10 Maintainability

The design of equipment shall incorporate the objective of efficient maintainability. The surveillance, testing, and maintenance of a system and its restoration to operational effectiveness shall be achieved at minimum cost with a minimum level of support services. UCRL 15673 shall be considered for system design.

1300-12.4.11 Labels

Equipment and any parts of that equipment to be used by personnel shall be identified with appropriate labels. Equipment and equipment parts include, but are not limited to, system and subsystem component groupings, individual components, control positions or modes, display markings, instructions, procedure manuals, storage spaces, access panels, and tools.

The label shall indicate clearly and concisely the function and purpose of the item being labeled. Unneccessary information (e.g., information used only for manufacturing purposes) shall not be included. Hierarchical labeling also shall be used to facilitate component location on control panels.

The label information shall be easy to understand. Words, symbols, and other markings in a label or instruction shall be unambiguous and accurate. The terminology used shall have commonly accepted meaning for all users.

Label design shall be consistent. The use of abbreviations and acronyms shall be minimized.

Various equipment labels placed on the same or similar pieces of equipment and serving similar functions shall use the same material, color, font type, relative location to component, general format, and other configuration features to promote simplicity and avoid clutter.

The terminology used for equipment, procedures, and training materials shall be the same for each case.

Permanent labels shall be attached to the specific component or equipment in such a manner that environmental conditions or usage by personnel will not remove or destroy the label.

Temporary labels shall be used only when necessary and shall be controlled administratively. They shall not obscure other information or equipment, and they shall be attached securely. If a temporary label is to designate a device that is out of service, the label shall be applied so that it prevents the use of that device. Other label criteria described in this section shall apply to temporary labels.

Labeling shall be legible and conform to human visual capabilities and limitations in regard to physical characteristics such as letter and symbol size, contrast, font simplicity, spacing and stroke width.

Properly designed mimic displays shall be used to improve the users understanding of the system.

Specific guidelines for addressing labeling considerations are contained in NUREG 0700, Section 6.6.; and MIL-STD-1472C, Section 5.5.

See Section 1040, Identifying Devices.

1300-13 ACCESSIBILITY AND USABILITY BY THE PHYSICALLY HANDICAPPED

Although special facilities may not generally offer opportunities for employment of physically handicapped persons within hazardous areas, consideration shall be given to employment opportunities in such areas as offices and other administrative or support areas. Suitable provisions shall be made in these areas where such opportunities exist and where handicapped persons would not be subjected to undue risk because of the need for rapid evacuation in the event of fire, explosion, or radiological or other hazards.

1304 PLUTONIUM PROCESSING AND HANDLING FACILITIES

1304-1 COVERAGE

Section 1300, General Requirements, shall apply. The requirements of Section 1300 are in *addition to* the requirements of that section and other applicable sections of these criteria, particularly those sections numbered -99.0, Nonreactor Nuclear Facilities-General.

PPHFs include facilities principally dedicated to processing and handling plutonium in substantial quantities, e.g., to be used in nuclear explosives production, nuclear reactor fuel assemblies, or heat source packages. What constitutes a "substantial quantity" or a "small quantity" depends on the quantity of each isotope, the physical and chemical form, and the specific process involved. A consideration of the hazard determines whether the facility should be classified as a PPHF.

These criteria shall be used for facilities processing and handling other transuranic radionuclides, such as americium, curium, neptunium, and californium. The activity and mass criteria stated above shall apply.

1304-2 OBJECTIVES

The design objective shall be to ensure that conservatively estimated consequences of normal operations and credible accidents are limited in accordance with the guidelines contained in Section 1300-1.4, Guidance on Limiting Exposure of the Public.

1304-3 NUCLEAR CRITICALITY SAFETY

Enclosures and material transport and transfer control systems shall be designed so that plutonium and moderating material in excess of posted limits cannot be added to otherwise criticality-favorable enclosures or areas.

1304-4 RADIATION PROTECTION

Because of the special characteristics of plutonium or possibly other materials with high specific activity or radiotoxicity, PPHFs shall meet the following requirements when they are applicable.

Facility design shall provide for the continuous monitoring of external radiation exposure levels in process areas such as hot cells and canyons during entries required for maintenance or repair operations.

The design professional shall consider the criteria provided in USNRC R.G. 3.35 for applicability to PPHFs.

Neutron shields in the form of water jackets shall be monitored for water loss.

Installed (fixed) air monitors for radioactive materials shall be designed with a minimum sensitivity of 8 DAC-hours.

1304-5 SPECIAL DESIGN FEATURES

In general, only hazardous gases or liquids that are necessary for a process shall be used in PPHFs. No natural gas for heating purposes shall be used unless the heating occurs in a separate building that is clearly isolated from the primary facility. Other flammable, explosive, corrosive, or toxic gases or liquids that are necessary to the process shall be handled under special control and isolated to avoid releases or reactions that might cause injury to workers, the public, or the environment. Those flammable gases that are necessary for a process shall be provided by a hard-piped system with the gas supply located outside of the facility in cylinders rather than from large capacity sources so as to limit the total quantity available in the event of a fire or explosion.

The design shall accommodate all planned plutonium handling (e.g., chemical or NDA analysis, shipping and receiving operations, packaging and unpackaging, as well as in-process storage). Provisions shall be made to minimize the buildup of packaging materials or packaged materials.

Pipes or other conduits for the transfer of plutonium in a product or waste liquid shall be at least double-walled or run within art enclosure that shall provide a second leak-tight barrier in the event of a DBA. Leakage from the primary pipe shall be collected in a geometrically favorable location. It shall be continuously detectable by a liquid-detection system or by a radiation-detection system.

Exhaust ventilation systems shall be provided with HEPA filtration to minimize the release of plutonium and other hazardous material through the exhaust path. In addition, intake ventilation systems shall also be provided with either HEPA filtration or fail-safe backflow prevention to minimize the release of plutonium and other hazardous material through the inlet path. Additional requirements and guidance are provided in Section 1550-99, Special Facilities.

Structures housing safety class items such as emergency diesel generators, the UPS, and the exhaust ventilation filtration system shall be designed to withstand the DBAs postulated for the PPHF.

The design professional shall consider the criteria presented in the following guides for applicability to PPHFs:

- R.G. 3.12
- R.G. 3.14
- R.G. 3.17

The design professional shall also consider the following criteria to ensure adequate materials control and accountability:

- In order to prevent the accumulation of nuclear materials containing scrap and/or off-standard process recyclable material within the facility equipment, space shall be provided for expeditious treatment or processing of these materials, as necessary, to allow their return to the main process.
- Space shall be provided within each MAA that is adequate for receiving, handling, storing, and measuring receipts.
- For processes involving solids, the process design shall facilitate efficient collection of spilled solids, performance of timely accountability measurements, and expeditious return of such solids to the processing line or scrap recovery system.
- To the extent practical, the shape of the building process areas shall be designed to facilitate surveillance. Irregular shapes shall be avoided as much as possible (i.e., cubes, cylinders, or parallel pipes shall be considered).

1304-6 CONFINEMENT SYSTEMS

1304-6.1 General

The following provisions shall be considered as typical for a PPHF confinement system. The actual confinement system requirements for a specific plutonium facility shall be determined on a case-by-case basis.

Generally, three confinement systems are used to achieve the confinement system objectives at PPHFs. They consist of the following:

- Primary confinement. Primary confinement is provided by piping, tanks, glove boxes, encapsulating material, and the like, and any off-gas system that controls effluent from within the primary confinement. It provides confinement of hazardous material to the vicinity of its processing.

- Secondary confinement. Secondary confinement is provided by walls, floors, roofs, and associated ventilation exhaust systems of the cell or enclosure surrounding the process material or equipment. Except in the case of glove box operations, the area inside this barrier is usually unoccupied; it provides protection for operating personnel.

- Tertiary confinement. Tertiary confinement is provided by the walls, floor, roof, and associated ventilation exhaust system of the facility. It provides a final barrier against release of hazardous material to the environment.

Which (if not all) of several barriers shall be designed to withstand a particular DBA shall be determined on a case-by-case basis. For example, the cell structure may be a more appropriate barrier than the process vessels in the instance of the DBE.

The effectiveness of each confinement barrier shall be checked analytically against all challenges it is expected to withstand without loss of function. This applies to any form of the hazardous material (gaseous, liquid, or solid) and its carring medium (i.e., airborne or spilled in a liquid).

Operation of support and protection systems such as the fire protection system shall not promote a failure of the principal confinement systems. Confinement systems shall be designed in accordance with ALARA concepts.

1304-6.2 Primary Confinement System

Primary confinement shall consist of barriers, enclosures, glove boxes, piping, vessels, tanks, and the like that contain plutonium. Its principal function is to prevent release of plutonium to areas other than where processing operations are normally conducted.

Primary confinement of plutonium processes that involves readily dispersible forms (e.g., solutions, powder or small fragments, gases) shall be provided by glove boxes or other fully confining enclosures. Hoods shall be used only when a hazard evaluation indicates the risk involved is acceptable. This evaluation shall consider the quantity of the material involved, the specific operation to be performed, and the chemical form of plutonium involved.

Primary confinement shall be designed, fabricated, tested, and maintained to a degree of quality assurance commensurate with its importance. QA criteria shall be specified at the preliminary design stage. Design features incorporated into the confinement system shall have been proven effective by extensive experience in similar applications or by formal prototype testing.

The integrity of the primary confinement system shall be maintainable through all normal operations, anticipated operational occurrences, and any DBA the primary barrier is required to withstand. Breaches in the primary confinement barrier that cannot be totally avoided or ruled out (e.g., due to glove or seal failure) must be compensated for by provision of adequate inflow of air or safe collection of spilled liquid.

Occasional breaches that are required for anticipated maintenance shall be made only under carefully controlled conditions. Provisions shall be made for storage of in-process material elsewhere, for temporary alternative barriers, and for adequate inflow of air to ensure contamination control. The exhaust ventilation system shall be sized to ensure radiological doses are maintained at ALARA levels in the event of the largest credible breach.

The process equipment and the process itself shall be designed to minimize the probability of fire, explosion, or corrosion that might breach the confinement barrier. Confinement enclosures for combustible metals shall provide self-contained fire detection and extinguishing capability. An inert atmosphere shall be required when pyrophoric forms (e.g., chips, filings, dust) of materials are being handled in the confinement enclosure. Halon systems shall not be used for enclosures handling pyrophoric metals due to its oxidizing reaction with the hot metal.

Primary confinement barrier(s) shall be provided between the process material and any auxiliary system (e.g., a cooling system) in a manner that minimizes risk of material transfer to an unsafe location or introduction of an undesirable medium into the process area. Differential pressure across the barrier(s) shall be used where appropriate.

The confinement philosophy represented by the foregoing requirements shall also be applied to other components that serve a primary confinement function, such as conveyor systems, material transfer stations, and ventilation/off-gas systems.

Special ventilation problems related to volatile organic liquids or finely divided pyrophoric metal are indirectly related to primary confinement and are discussed in Section 1550-99, Special Facilities.

For further primary confinement design criteria, see Section 1161, Enclosures.

1304-6.3 Secondary Confinement System

The secondary confinement system shall consist of the confinement barriers and associated ventilation systems that confine any potential release of hazardous material from primary confinement. Because plutonium processing commonly is conducted in glove boxes as the primary confinement, the functional requirements below refer to the operating area boundary and the ventilation system serving the operating area as the secondary confinement system.

The integrity of the secondary confinement shall be maintainable through all normal operations, anticipated operational occurrences, and any DBA the secondary barrier is required to withstand. If the secondary barrier is required to withstand the DBE, it shall be designed in accordance with criteria in Section 0111-99.0, Nonreactor Nuclear Facilities-General. Other DBAs, such as the design basis fire, shall also be considered as potential causes of loss of secondary confinement. ALARA concepts shall be incorporated in secondary confinement system design to minimize consequences on the operators and the public and environment.

Design features incorporated into the confinement system shall have been proven effective by extensive experience in similar applications or by formal prototype testing.

Continuous monitoring capability shall be provided to detect loss of proper differential pressure with respect to the process area. Release of hazardous material to the operating area shall also be continuously monitored. Commensurate with the potential hazards, consideration shall be given to the use of redundant sensors.

Penetrations of the secondary barrier shall have positive seals on permanent penetrations (e.g., pipes, ducts) or double closure with controlled secondary to primary leakage on pass-through penetrations (e.g., personnel air locks and enclosed vestibules).

Ventilation systems associated with confinement shall be designed with adequate capacity to ensure proper direction and velocity of air flow in the event of the largest credible breach in the barrier.

1304-6.4 Tertiary Confinement System

Tertiary confinement shall be provided by the building or outer structure of the facility. For some of the DBAs, it represents the final barrier to release of hazardous material to the environment; for others, such as the design basis tornado, it is the barrier that protects the rest of the facility from damage.

The integrity of the tertiary confinement system shall be maintainable throughout normal operations, anticipated operational occurrences, and any DBA the tertiary barrier is required to withstand.

ALARA concepts shall be incorporated in tertiary confinement system design to minimize consequences on operators, the public, and the environment.

1304-7 EFFLUENT CONTROL AND MONITORING

1304-7.1 Radioactive Solid Waste

The solid waste typically associated with a PPHF (e.g., discarded equipment, tools, rags, filters, and gloves) may be contaminated with plutonium metal (fragments or turnings) or various compounds in powder form. It may contain contaminated liquid in solid absorbent material.

Plutonium-contaminated solid waste shall be collected and handled in a location specifically designed to provide favorable geometry for criticality safety and means for packing and safe transfer of TRU waste.

Assay capability shall be provided to allow identification of TRU waste. Measurement Sensitivity shall satisfy both waste management and material accountability requirements.

Volume reduction capability shall be provided where analysis demonstrates that cost benefits will offset installation costs.

Cleaning capability to reduce typical waste from TRU category to low-level category shall be provided unless it can be demonstrated that such capability is not necessary or practical.

Transfer capability shall include transfer of TRU waste in approved containers by approved methods.

1304-7.2 Radioactive Liquid Waste

The liquid radioactive wastes typically associated with PPHFs are plutonium-contaminated liquids and nonrecoverable amounts of process liquids (e.g., liquid filter sludge, wet grinding effluent, and contaminated solvents and oils). It may include contaminated laundry waste. The design of the liquid waste handling system shall consider these forms and others specific to the process.

Plutonium-contaminated liquid waste shall be collected in favorable geometry tanks with stirrers or other accepted mixing methods, sampling devices, and volume measuring devices. An appropriate transfer system shall be provided that includes sufficient holdup capacity to allow conclusive sampling before transfer to treatment locations. Fire suppression water drains shall be designed to minimize transfer of SNM to other locations. The tankage for this purpose is not required to be critically favorable.

Liquid radioactive wastes require treatment for removal of plutonium. Adequate holdup of liquid effluents shall be provided to accommodate any anticipated treatment delays or monitoring breakdowns. Appropriate design, monitoring, and administrative controls shall ensure that liquid effluent radioactive concentrations are below the limits on discharge specified in the directive on Radiation Protection of the Public and the Environment in the DOE 5400 series. In addition, to the extent practical, releases of radioactive liquid wastes shall be maintained at ALARA levels.

The design professional shall consider the criteria provided in USNRC R.G. 3.10 for applicability to PPHFs.

1304-7.3 Effluents

1304-7.3.1 Airborne Effluents

The airborne radioactive effluents typically associated with PPHFs are furnace off-gas, airborne dust, off-gas from solvent processes, and corrosive vapor or mists from dissolvers. The design of airborne effluent systems shall consider and minimize plutonium holdup at locations in off-gas and ventilation ductwork and include provisions to detect and monitor the buildup of material and for its recovery. Appropriate nuclear criticality safety provisions shall be applied to the airborne effluent systems. Effluent monitoring and controls shall comply with the requirements of 40 CFR 61; the directive on Radiation Protection of the Public and the Environment in the DOE 5400 series; the directive on Radiological Effluent Monitoring and Environmental Surveillance in the DOE 5400 series; and all applicable Federal, State, and local requirements. In addition, releases of airborne effluents shall be minimized by application of ALARA design principles.

All exhaust outlets that may contain plutonium contaminants shall be provided with two monitoring systems. These monitoring systems shall comply with Section 1589-99.0.1, Radioactive Airborne Effluents. The monitoring capability shall cover the range from normal effluent concentrations to the maximum concentration expected from a credible accidental release.

1304-8 DECONTAMINATION AND DECOMMISSIONING

The PPHF shall include a decontamination area within the process or operating area. This area shall be furnished with all necessary cleaning equipment, radioactivity monitors, waste handling capability, and safety features to safely perform equipment cleaning tasks.

Air cleaning devices shall be located as close to the source of contamination as practicable to avoid the unnecessary spreading of the contamination into ducts, conveyors, or other process areas. This would include the filtration of glovebox exhaust air prior to the exhaust air entering a duct leading to a plenum.

Protection shall be provided for bare floors, walls, and ceilings, particularly for structurally important parts of the building. Protection shall be in the form of strippable coatings or durable coatings for which effective cleaning methods have been developed.

Surfaces in operating or process areas shall have no seams, cracks, or rough or absorbent surfaces.

In areas that are most likely to become contaminated, adequate access shall be provided, such as crawl spaces, piping tunnels, and hatches into ductwork, to facilitate decontamination.

The design of equipment shall include features and characteristics to minimize its contamination and facilitate decontamination.

1305 PLUTONIUM STORAGE FACILITIES

1305-1 COVERAGE

Section 1300, General Requirements, shall apply. These requirements are *in addition to* the requirements of that section and other applicable sections of these criteria, particularly those sections numbered -99.0, Nonreactor Nuclear Facilities-General.

These criteria shall be applied in the planning and design of PSF that will contain strategic (Category I as defined in the DOE 5632 series) amounts of plutonium. They are not applicable to "in process" or "in use" material, to material in assembly cells for use in weapons, or to material that is packaged in accordance with the requirements of DOE 5480.3 and is awaiting transportation or has been received and is awaiting disposition. However, these criteria do apply to joint storage with other transuranic elements and uranium. The stored plutonium can be in the form of a liquid, solid, or gas.

These general design criteria shall also be considered for application to facilities storing other transuranic radionuclides, such as neptunium and californium.

1305-2 OBJECTIVES

The design objective shall be to ensure that conservatively estimated consequences of normal operations and credible accidents are limited in accordance with the guidelines contained in Section 1300-1.4, Guidance on Limiting Exposure of the Public.

1305-3 NUCLEAR CRITICALITY SAFETY

ANS 8.6 shall apply. Favorable geometry, as implemented by storage rack design, is the preferred method of ensuring nuclear criticality safety. The use of fixed neutron absorbing materials shall be considered. When fried neutron absorbers are used, the rack design shall include provisions to verify the absorber's continual efficacy and to prevent their inadvertent removal by mechanical or chemical action. Storage racks shall be designed to maintain their integrity during and following a DBE, and the DBAs they are required to withstand.

In addition, the design professional shall consider the criteria provided in R.G. 3.43 for applicability to PSFs.

1305-4 SPECIAL DESIGN FEATURES

PSF systems, components, and structures shall be designed to provide confinement of radioactive materials under normal operations, anticipated operational occurrences, and the DBA conditions they are required to withstand. The design shall ensure that the degree of confinement is sufficient to limit releases to the environment to the extent that the guidelines referenced in Section 1300-1.4, Guidance on Limiting Exposure of the Public, are not violated. PSF systems shall be designed incorporating ALARA concepts.

The design shall accommodate all planned plutonium handling (e.g., analysis, shipping and receiving operations, packaging and unpackaging, as well as storage). Provisions shall be made to minimize the buildup of packaged materials or packaging materials. Receiving operations involving removal of radioactive material from protective shipping containers shall be performed in the unpackaging room(s).

Facility design, to the maximum extent practical, shall provide sufficient versatility to accommodate equipment for programmatic changes and modifications and for multishift operations.

To expedite recovery from DBAs and provide facility versatility, modular construction concepts shall be used, where feasible.

The design shall provide sufficient spacing between compartments to facilitate relocation and maintenance of equipment and case of manual or automatic storage operations.

No hazardous gases or liquids shall be used in PSFs. No natural gas for heating purposes shall be used unless the heating occurs in a separate building that is clearly isolated from the primary facility. The storage building(s), where practical, shall be rectangular, windowless and arranged in repetitive bays and compartments.

Facility layout shall provide for efficient cleaning, maintenance, and ease of inspection.

Facility design shall facilitate expeditious identification, inventory, placement, and retrieval of storage containers.

New storage facilities shall be physically separated from process operations, storage of nonnuclear materials or equipment, and functions not directly required for storage operations.

Combustible packaging materials shall be stored in metal containers or structures outside of a PSF in a location that shall not endanger the storage facility or stored material if a fire occurs in the packaging material. The need to provide automatic fire suppression systems for these areas shall be considered in accordance with Section 1530-2.3, Maximum Possible Fire Loss.

Layout of floor and access areas shall consider the requirements for secure location of storage containers, traffic control, and segregation.

Design of storage tanks for aqueous solutions of plutonium shall ensure that they are geometrically favorable with respect to nuclear criticality. When there is a tendency for solids to precipitate, vessels shall be instrumented to detect the buildup of solids and designed to facilitate removal of solids.

Suitable physical compartmentalization shall be provided, as determined from the safety analysis, to limit the quantity of stored materials in each compartment to safe levels; ensure the necessary access features and controls; and satisfy the loss limitation criteria in Section 0110-99.0.7, Loss Limitations.

Cautionary systems (e.g., visual or audible alarms, or other warning systems) or interlocks shall be provided to prevent inadvertent entry into hazardous areas.

All safety alarm systems shall annunciate inside and outside of the PSF so as to identify hazardous areas to anyone present in either area. The need for visual alarm devices within the facility, in addition to audible alarm devices, shall be considered.

Storage racks shall be noncombustible and designed to securely hold storage containers in place, ensure proper separation of storage containers, and maintain structural integrity under normal operations, anticipated operational occurrences, and DBA conditions. These racks shall be designed as safety class items.

Door locations shall be coordinated with aisles to facilitate access to stored material for loading and unloading of material, for use of fire fighting equipment, and for compliance with NFPA 101.

Bumpers shall be provided where necessary to minimize potential damage to the structure of racks from handling equipment.

The design shall provide for sufficient spacing and arrangement of compartments and/or containers to facilitate the taking of inventories. Vault doors, racks, and containers shall be designed to accommodate the application of TIDs. Adequate space for measurement capability shall be provided for the required inventory verification and/or confirmation. An automated vault surviellance system shall be provided where excessive radiation exposure would result from entering for material control and accountability purposes. The design of the vault and/or system shall facilitate the daily and other inventory requirements of DOE 5633.3. Those areas of the facility where attractive SNM is stored (e.g., plutonium product storage) should be located in the least accessible (to an intrusion force) area of the plant.

1305-5 CONFINEMENT SYSTEMS

1305-5.1 General

The following provisions are typical for a PSF confinement system. The actual confinement system requirements for a specific PSF shall be determined on a case-by-case basis.

The degree of confinement required shall suit the most restrictive hazards anticipated. Therefore, consideration shall be given to the type, quantity, physical and chemical form, and packaging of the materials to be stored. For materials in a form that is not readily dispersible, a single confinement barrier may be sufficient. However, for more readily dispersible materials such as liquids and powders and for materials with inherent dispersal mechanisms, such as pressurized cases and pyrophoric forms, multiple confinement barriers are required. Qualified packages (such as encapsulation or DOT-approved shipping containers) may be considered to be barriers.

Generally, for the most restrictive cases anticipated, the use of three confinement systems shall be considered. The primary confinement shall be the cladding or the storage container (e.g., canning). Secondary confinement shall be established by compartments with their ventilation systems. The tertiary or final confinement shall be the building structure and its ventilation system.

Operation of support and protection systems such as fire protection shall not promote the failure of the principal confinement systems.

Coding systems shall be provided, as required.

Ingress and egress to the compartments shall be controlled through the use of access ways (e.g, airlocks, enclosed vestibules).

Exhaust ventilation systems shall be provided with HEPA filtration to minimize the release of plutonium and other hazardous material through the exhaust path. In addition, inlet ventilation systems shall also be provided with either HEPA filtration or fail-safe backflow prevention to minimize the release of plutonium and other hazardous material through the inlet path.

1305-5.2 Primary Confinement System

Cladding or storage containers, as appropriate, shall provide primary confinement during normal operation, anticipated operational occurrences, and for all DBAs they are required to withstand.

The cladding or storage containers shall be designed to provide a corrosion-resistant confinement for fuel assemblies and to prevent an uncontrolled release of radioactive material.

Special design features shall be considered to ensure safe introduction, removal, and handling of stored plutonium. These handling systems and equipment shall be designed to protect against the dropping of storage containers, fuel assemblies, and other items on the stored plutonium.

1305-5.3 Secondary Confinement System

The compartments and their ventilation systems make up the secondary confinement system.

The secondary confinement system shall be designed to function during normal operations, anticipated operational occurrences, and for all DBAs it is required to withstand. It shall be designed as a safety class system and be capable of performing its necessary functions following a DBE.

Penetrations of the secondary confinement barrier shall have positive seals to prevent the migration of contamination. The use of positive seals shall be considered for penetration of enclosures within the facility building to ensure the availability of proper ventilation flow paths and to prevent the migration of contamination within the facility.

The need for special ventilation systems for confinement purposes shall be based on the results of the safety analysis. In general, each compartment shall be supplied with ventilation air from the building ventilation system, and shall be provided with separate exhaust ventilation handled by a system with sufficient capacity to ensure an adequate ventilation flow in the event of a credible breach in the compartment confinement barrier. Pressure in the compartments shall be negative with respect to the building ventilation system.

1305-5.4 Tertiary Confinement System

The facility building and its ventilation system compose the tertiary confinement system.

The tertiary confinement system is not required to be protected from tornado missiles or missiles from other external sources (e.g., explosions on nearby transportation routes), but shall be designed to prevent massive collapse of building structures or the dropping of heavy objects onto the stored plutonium as a result of building structural failures and remain functional to the extent that the guidelines in Section 1300-1.4.2, Accidental Releases, are not violated.

Penetrations of the building confinement barriers shall have positive seals to prevent the migration of contamination.

Air locks or enclosed vestibules shall be provided for access through confinement barriers.

1305-6 EFFLUENT CONTROL AND MONITORING

1305-6.1 General

Routine wastes from PSFs will normally be in the form of uncontaminated and radioactive solids and liquids. A principal design objective for the waste management systems shall be to provide facilities and equipment to handle these wastes safely and effectively.

1305-6.2 Radioactive Solid Waste

The design shall include provisions for the safe collection, packaging, inventory of, storage, and loading for transport of solid waste that is contaminated with radioactive material. These provisions shall include allocation of adequate space for sorting and safe temporary storage of solid waste, equipment for assay of the waste, and facilities for volume reduction appropriate to the types and quantities of solid waste expected to be produced. All packages containing radioactive solid waste are required to be monitored, both before being moved from generation sites and volume reduction processes to temporary storage locations and before being loaded for transport to a disposal site.

1305-6.3 Radioactive Liquid Waste

1305-6.3.1 Industrial Wastes

Industrial wastes such as discharge from mop sinks shall be collected and transferred to a liquid waste treatment facility or similar type of treatment area. Consideration shall be given to the installation of a retention system. The treatment process shall be designed to reduce radioactive materials to concentrations well below the guidelines in the directive on Radiation Protection of the Public and the Environment in the DOE 5400 series, using the best available technology economically achievable.

1305-6.3.2 Decontamination Wastes

Decontamination wastes shall be collected and monitored near the source of generation before batch-wise discharge through appropriate pipelines or by tank transfer to a liquid waste treatment facility or area. These wastes shall be individually collected at the PSF in storage tanks that are equipped with stirrers or other accepted mixing methods, sampling devices, volume measuring devices, and transfer systems. Waste storage tanks and transfer lines shall be designed and constructed so that any leakage shall be detected and contained before it reaches the environment. Transfer lines shall have inspection/collection pits at practicable intervals into which leakage can drain by gravity. The use of double-walled transfer pipelines or multi-pipe encasements as specified in Section 1300-7.4, Transfer Pipes and Encasements, shall be considered. Nuclear criticality safety shall be considered in the design of these collection and monitoring systems.

1305-6.4 <u>Effluents</u>

1305-6.4.1 Airborne Effluents

All airborne effluents from confinement areas shall be exhausted through a ventilation system designed to remove particulate material, vapors, and gases as needed to comply with Section 1300-1.4.3, Routine Releases.

All exhaust outlets that may contain plutonium contaminants shall be provided with two monitoring systems. These monitoring systems shall comply with Section 1589-99.0.1, Radioactive Airborne Effluents.

1306 <u>UNIRRADIATED ENRICHED URANIUM STORAGE FACILITIES</u>

1306-1 COVERAGE

Section 1300, General Requirements, shall apply. These requirements are *in addition to* the requirements of that section and other applicable sections of these criteria, particularly those sections numbered -99.0, Nonreactor Nuclear Facilities-General.

This section is specifically applicable to dry type UEUSF used for the storage of UEU. The UEU may be in the form of a solid, liquid or gas.

These criteria are not applicable to "in process" or "in use" material, to material in assembly cells for use in weapons, or to material that is packaged in accordance with the requirements of DOE 5480.3 and is awaiting transportation or has been received and is awaiting disposition. In addition, UEU fuel storage facilities that are part of a reactor facility are not covered by this section. They are covered by DOE 5480.6.

1306-2 OBJECTIVES

The design objectives shall ensure that conservatively estimated radiological accident consequences are limited in accordance with the guidelines contained in Section 1300-1.4.2, Accidental Releases.

1306-3 NUCLEAR CRITICALITY SAFETY

Favorable geometry, as implemented by storage rack design, is the preferred method of ensuring nuclear criticality safety. The use of fixed neutron absorbing materials shall be considered. When fixed neutron absorbers are used, the rack design shall include provisions to verify the absorbers’ continual efficacy and to prevent their inadvertent removal by mechanical or chemical action. Storage racks shall be designed to maintain their integrity during and following a DBE and the DBAs they are required to withstand.

The design professional shall consider the criteria provided in USNRC R.G. 3.43 for applicability.

1306-4 RADIATION PROTECTION

Radiation protection provisions for UEUSF shall take into account that the combination of the radioactivity level of UEU, its confinement in cladding or storage containers, and the lack of significant operations involving the UEU may reduce the radiation hazards at UEUSF.

1306-5 SPECIAL DESIGN FEATURES

UEUSF systems, components, and structures shall be designed to provide confinement of radioactive materials under normal operations, anticipated operational occurrences, and the DBA conditions they are required to withstand. The design shall ensure that the degree of confinement is sufficient to limit releases to the environment to the extent that the dose guidelines referenced in Section 1300-1.4, Guidance on Limiting Exposure of the Public, are not exceeded. The design shall incorporate ALARA concepts to minimize overall impacts on operators, the public, and the environment.

The design shall accommodate all planned UEU handling (e.g., analysis, shipping and receiving operations, packaging and unpackaging, as well as storage). Provisions shall be made to minimize the buildup of packaged materials or packaging materials. Receiving operations involving removal of radioactive material from protective shipping containers shall be performed in the unpackaging room(s).

Facility design, to the maximum extent practical, shall provide sufficient versatility to accommodate equipment for programmatic changes and modifications and for multishift operations.

To expedite recovery from DBAs and provide facility versatility, modular construction concepts shall be used, where feasible.

The design shall provide sufficient spacing between compartments to facilitate relocation and maintenance of equipment and ease of manual or automatic storage operations.

No hazardous gases or liquids shall be used in UEUSFs. No natural gas for heating purposes shall be used unless the heating occurs in a separate building that is clearly isolated from the primary facility.

The storage building(s), where practical, shall be rectangular, windowless and arranged in repetitive bays and compartments.

Facility layout shall provide for efficient cleaning, maintenance, and ease of inspection.

Facility design shall facilitate expeditious identification, inventory, placement, and retrieval of storage containers.

New storage facilities shall be physically separated from process operations, storage of nonnuclear materials or equipment, and functions not directly required for storage operations.

Combustible packaging materials shall be stored in metal containers or structures outside of a UEUSF in a location that shall not endanger the storage facility or stored material should a fire occur in the packaging material. The need to provide automatic fire suppression systems for these areas shall be considered in accordance with Section 1530-2.3, Maximum Possible Fire Loss.

Layout of floor and access areas shall consider the requirements for secure location of storage containers, traffic control, and segregation.

Design of storage tanks for aqueous solutions of enriched uranium shall ensure that they are geometrically favorable with respect to nuclear criticality safety. When there is a tendency for solids to precipitate, vessels shall be instrumented to detect the buildup of solids and designed to facilitate removal of solids.

Suitable physical compartmentalization shall be provided, as determined from the safety analysis, to limit the quantity of stored materials in each compartment to safe levels; ensure the necessary access features and controls; and satisfy the loss limitation criteria in Section 0110-99.0.7, Loss Limitations.

Cautionary systems (e.g., visible or audible alarms, or other warning systems) or interlocks shall be provided to prevent inadvertent entry into hazardous areas.

All safety alarm systems shall annunciate inside and outside of the UEUSF so as to identify hazardous areas to anyone present in either area. The need for visual alarm devices within the facility, in addition to audible alarm devices, shall be considered.

Storage racks shall be noncombustible and designed to securely hold storage containers in place, ensure proper separation of storage containers, and maintain structural integrity under normal operations, anticipated operational occurrences, and DBA conditions. These racks shall be designed as safety class items.

Door locations shall be coordinated with aisles to facilitate access to stored material, for loading and unloading of material, for usc of fire fighting equipment, and for compliance with NFPA 101.

Bumpers shall be provided where necessary to minimize potential damage to the structure or racks from handling equipment.

The design shall provide for sufficient spacing and arrangement of compartments and/or containers to facilitate the taking of inventories. Vault doors, racks, and containers shall be designed to accommodate the application of TIDs. Adequate space for measurement capability shall be provided for the required inventory verification and/or confirmation. The design of the vault system shall facilitate the daily and other inventory requirements of DOE 5633.3. Those areas of the facility where attractive SNM is stored shall be located in the least accessible (to an intrusion force) area of the plant.

1306-6 CONFINEMENT SYSTEMS

1306-6.1 General

The following provisions are typical for a UEUSF confinement system. The actual confinement system requirements for a specific UEUSF shall be determined on a case-by-case basis.

The degree of confinement required shall suit the most restrictive hazards anticipated. Therefore, consideration shall be given to the type, quantity, and physical and chemical form of the materials to be stored. For materials in a form that is not readily dispersible, a single confinement barrier may be sufficient. However, for more readily dispersible materials such as liquids and powders and for materials with inherent dispersal mechanisms, such as pressurized cases and pyrophoric forms, multiple confinement barriers shall be considered.

Generally, for the most restrictive case anticipated, the use of three confinement systems shall be considered. The primary confinement shall be the UEU cladding or the storage container (e.g., canning). Secondary confinement shall be established by compartments with their ventilation systems. The tertiary or final confinement shall be the building structure and its ventilation system.

Operation of support and protection systems such as fire protection shall not promote the failure of the principal confinement systems.

Cooling systems shall be provided, as required.

Ingress and egress to the compartments shall be controlled through the use of access ways (e.g., airlock, enclosed vestibules).

1306-6.2 Primary Confinement System

The UEU cladding or storage containers, as appropriate, shall provide primary confinement during normal operations, anticipated operational occurrences, and for all DBAs they are required to withstand.

The UEU cladding or storage containers shall be designed to provide a corrosion-resistant confinement for the fuel assemblies and other UEU to prevent an uncontrolled release of radioactive material.

Special design features shall be considered to ensure safe introduction, removal, and handling of UEU. These handling systems and equipment shall be designed to protect against the dropping of storage containers, UEU assemblies, and other items on the stored UEU. The design shall consider the use of geometric constraints to avoid criticality accidents.

1306-6.3 Secondary Confinement System

The compartments and their ventilation systems make up the secondary confinement system.

The secondary confinement system shall be designed to function during normal operations, anticipated operational occurrences, and for all DBAs it is required to withstand. It shall be designed as a safety class system and capable of performing its necessary functions following a DBE.

Penetrations of the secondary confinement barrier shall have positive seals to prevent the migration of contamination. The use of positive seals shall be considered for penetration of enclosures within the facility building to ensure the availability of proper ventilation flow paths and to prevent the migration of contamination within the facility.

The need for special ventilation systems for confinement purposes shall be determined by the safety analysis In general, each compartment shall be supplied with ventilation air from the building ventilation system, and shall be provided with separate exhaust ventilation handled by a system with sufficient capacity to ensure an adequate ventilation flow in the event of a credible breach in the compartment confinement barrier. Pressure in the compartments shall be negative with respect to the building ventilation system.

1306-6.4 Tertiary Confinement System

The facility's building and its ventilation system compose the tertiary confinement system.

The tertiary confinement system is not required to be protected from tornado missiles or missiles from other external sources (e.g., explosions on nearby transportation routes), but shall be designed to prevent massive collapse of building structures or the dropping of heavy objects onto the stored UEU as a result of building structural failures and remain functional to the extent that the guidelines in Section 1300-1.4.2, Accidental Releases, are not violated.

Penetrations of the building confinement barriers shall have positive seals to prevent the migration of contamination.

1306-7 WASTE MANAGEMENT

Waste management provisions for UEUSFs shall take into consideration that, generally, the quantities of radioactive waste generated are small because of the passive nature of a UEUSF.

The decontamination of storage and handling equipment will result in solid and liquid wastes of low specific activity. Packaging and shipping materials may also be a source of solid waste.

1306-8 EFFLUENT CONTROL AND MONITORING

1306-8.1 Radioactive Solid Waste

The solid radioactive wastes typically associated with UEUSFs that shall be considered during the design include but are not limited to packaging and shipping materials, gloves, rags, and mops. Nuclear criticality safety shall be considered in the design of the radioactive solid waste processing facility.

1306-8.2 Radioactive Liquid Waste

1306-8.2.1 Process Wastes

The liquid radioactive wastes typically associated with UEUSFs that shall be considered during the design include but are not limited to floor wash down liquids accumulated from equipment maintenance and leaks. Nuclear criticality safety shall be considered in the design of the liquid radioactive waste processing facility.

1306-8.3 Effluents

1306-8.3.1 Airborne Effluents

The airborne radioactive wastes associated with UEUSFs that shall be considered during the design include but are not limited to the airborne releases associated with the venting of storage containers. Cladding or canning failure during dry storage is also a source of such wastes.

All airborne effluents from confinement areas shall be exhausted through a ventilation system designed to remove particulate material, vapors, and gases as needed to comply with the requirements referenced in Section 1300-1.4.3, Routine Releases.

All exhaust ducts and stacks that may contain enriched uranium contaminants shall be provided with two monitoring systems. These monitoring systems shall comply with Section 1589-99.0.1, Radioactive Airborne Effluents.

1307 EXPLOSIVES FACILITIES

1307-1 COVERAGE

1307-1.1 General

Section 1300, General Requirements, shall apply. These requirements are in *addition to* the requirements of that section and other applicable sections of these criteria, particularly those sections numbered -99.0, Nonreactor Nuclear Facilities-General, and -99.4, Explosives Facilities.

These criteria apply to DOE explosives facilities, with specific applicability to DOE nuclear munitions (explosives-plutonium) facilities.

1307-1.2 Applicability

These criteria shall be followed in:

- Siting, planning, and design of any new facilities in which explosives are stored, handled, or processed

- Redesign of any existing facilities where changes in activities will result in a change to a more hazardous class (e.g., a change from Class II to Class I). See Glossary for definition of explosives hazard Class I and Class II. Where changes in activities will not result in a change to a more hazardous class, these criteria are not mandatory.

1307-1.3 Nonapplicability

These design criteria are not applicable to:

- Portable buildings used at specific nuclear test shot locations

- Facilities in which experimental or laboratory-type operations are conducted and where no more than 500 grams of explosives are involved, as further described in (a) and (b), below. However, quantity-distance separation must be provided between the laboratory and other buildings containing explosives based on the quantity of explosives in those buildings; such operations include, but are not limited to, small scale formulation work, chemical, physical and thermal analysis, and sensitivity tests.

  (a) Experimental and laboratory facilities are exempt from quantity-distance criteria where operations involving explosives in quantities of 10 grams or less (plutonium may be present) are conducted under DOE operating-contractor-approved SOPs.

  (b) Experimental and laboratory facilities are exempt from quantity-distance criteria where operations involving explosives in quantities between 10 and 500 grams (plutonium shall not be present) are conducted, subject to formal waivers approved by the operating contractor safety organization and issued in writing by the operating contractor management.

1307-2 OBJECTIVES

The objectives of these criteria are to ensure that facility design will achieve a level of safety for DOE explosives facilities specified in DOE/EV 06194 to reduce the risk of an accidental detonation and, in such an event, prevent fatalities, minimize injuries, control plutonium dispersal, prevent propagation, and minimize property loss.

The cardinal principle to be observed in any location or operation involving explosives, ammunition, severe fire hazards, or hazardous materials is to limit the exposure of a minimum number of people, for a minimum time, to a minimum amount of material consistent with safe and efficient operation.

1307-3 NUCLEAR CRITICALITY SAFETY

Where nuclear criticality is a consideration, the design of criticality alarm systems shall comply with ANS 8.3. Other nuclear criticality safety measures shall comply with DOE/DNA TP 20-7.

1307-4 SPECIAL DESIGN FEATURES

1307-4.1 General Criteria

1307-4.1.1 Siting of Explosives Facilities

General

The design of all new explosives buildings shall conform to the DOE explosives safety requirements established in DOE/EV 06194 and implemented in these criteria. For a tabular summary of the types of protective design established by these criteria, see Table 1307-4.1.1. Protective construction design features are specified in TM 5-1300 and DOE/TIC 11268.

Studies necessary to provide the technical basis for location, engineering, design, and operation (under normal and potential DBA conditions) of the buildings shall follow DOE/EV 06194 and DOD 6055.9 for establishing explosives quantity-distance separation DOE 4300.1B and Section 0200-1, Facility Siting, for the requirements for new site selections; and Section 1300-1.4.2, Accidental Releases, for radiological guidelines for accidental releases.

Hazardous Fragments

DOD 6055.9 requires that the minimum distance for protection from hazardous fragments to facility boundaries and specific critical facility and personnel exposures will be 1250 feet for explosives quantities of 101 to 30,000 lbs and 670 feet for 100 lbs or less of hazard Class/Division 1.1 explosives, unless it can be shown that there will be no hazardous fragments or debris at lesser distances. It is not intended that these minimum fragment distances be applied to operating facilities or dedicated support functions within an operating line. For these exposures, the DOE criteria for Class I, II, III, or IV activities with appropriate quantity-distance separations are the required protection levels.

Buildings or areas that are separated from explosives bays by inhabited building distances as determined by blast overpressures may provide an adequate degree of protection to personnel and facilities from fragment hazards from an explosives accident. However, for some explosives activities, the separation distance to inhabited buildings, public traffic routes, and open areas where personnel congregate may have to be increased beyond the distances specified for blast overpressures because of these potential fragment hazards.

1307-4.1.2 Hazard Class Activity

New facilities shall be designed and constructed to accommodate the highest hazard class activity for which they are to be used. Where an activity can be assigned to more than one hazard class, the facility shall be designed and constructed to meet the criteria of the most stringent hazard class.

The contract administrator (Head of Field Organization) shall be responsible for approving the hazard classification of all explosives activities prior to the design of the facilities in which the activities are to be conducted.

Table 1307-4.1.1 Explosives Facilities: Protective Design Requirements by Type of Activity

	Protective Design Required						
Type of Activity	DOE/EV/06194 Operational Requirements for Activity Involved	Explosion Protection for Personnel In Other Occupied Areas Including Adjacent Bay	Explosion Protection for All Personnel (Remote Operation)	Control of Plutonium in Event of an Explosion	High Level Protection from Natural Phenomena	Normal Protection from Natural Phenomena***	Radiological Considerations
Class I Activities							
Explosives Only	X	X	X			X	
HE-Pu* Cased							
HE-Pu* Uncased							
Class II Activities							
Explosives Only	X	X				X	
HE-Pu Cased	X	X			X		X
HE-Pu Uncased	X	X		X	X		X
Class III Activities							
Explosives Only	X					X	
HE-Pu Cased		.... NOT PERMITTED					
HE-Pu Uncased		.... NOT PERMITTED					
Class IV Activities							
Explosives Only	X**					X	
HE-Pu Cased	X**					X	X
HE-Pu Uncased	X**					X	X
Support Area	X					X	

* Class I activities with either cased or uncased HE-Pu or IHE-Pu are not permitted, except where such activities are justified from a nuclear explosives safety study performed in accordance with DOE 5610.3.

** Class IV bays need only to be sited and designed to withstand the effects of blast overpressure, structural collapse and missiles (hazardous fragments) from an adjacent bay.

*** These facilities need only be designed to provide protection acceptable with normal DOE loss criteria.

Definitions of explosives hazard classes by activity are found in the Glossary.

1307-4.1.3 Design Basis

The appropriate DBAs shall be postulated and the design of new explosives buildings shall ensure that any structure, confinement system(s), ventilation systems, fire suppression/ detection systems, or other systems required to be safety class will meet the conditions imposed by the consequences of the DBAs.

1307-4.1.4 Unproven Facility Design

For an unproven facility design, either a validated model or full-scale test is required to ensure structural adequacy unless a high degree of confidence can be provided by calculations or other means. The contract administrator (Head of Field Organization) shall concur in any determination regarding test requirements.

1307-4.1.5 Support Buildings

Support buildings are not specifically addressed in these criteria because the degree of protection afforded must be based on the function housed and its effect on the accomplishment of the mission of the installation. Siting of support buildings shall conform to the requirements of DOE/EV 06194 and DOD 6055.9.

1307-4.2 Facility Criteria

1307-42.1 General

These criteria are presented below in two categories:

- Facilities that deal with explosives only
- Facilities with explosives and nuclear material present, specifically plutonium.

1307-4.2.2 Explosives-Only Bays–Facilities for Storage, Handling, and Processing

In the planning of explosives activities to be performed and in the design of explosives bays to satisfy these activity requirements, a basic tenet shall be to limit explosives activity hazards exposure to a minimum number of personnel. Additionally, each bay housing an explosives activity shall have levels of protection based on the explosives hazard class (see Glossary) determined for the activity. The levels of protection may be accomplished by equipment design, structural design, operation separation and/or the provision of operational shields as defined in DOE/EV 06194.

Class IV Explosives Bays

Bays for Class IV (negligible probability of accidental initiation) activities shall provide protection from fire hazards effects. Because accidental detonation is not considered credible, Class IV bay shall be sited and designed to withstand the effects of blast overpressure, structural collapse, and missiles (hazardous fragments) from adjacent facilities.

Class III Explosives Bays

Bays for Class III (low accident potential) activities shall provide protection from explosion propagation from bay to bay within buildings and between buildings that are located at the intraline or magazine separation distance. Minimum separation distances may be reduced when explosives bays are designed to adequately contain the effects of an accident (blast overpressures and missiles).

Class II Explosives Bays

Bays for Class II (moderate accident potential) activities shall, in addition to complying with the requirements for Class III bays, include design to prevent fatalities and severe injury to personnel in all occupied areas other than the bay of occurrence. For the purpose of the Class II category, access ramps and plant roads are not considered occupied areas. Prevention of fatalities and severe injuries is satisfied where personnel in occupied areas other than the bay of occurrence will not be exposed to:

- Overpressures greater than 15 psi maximal effective pressure. This is the threshold pressure for lung damage.
- Structural collapse resulting from overpressures or debris impact. Structural collapse is the loss of structural integrity from the failure of a structural component as a direct result of the facility’s being subjected to various loadings (judged in accordance with the ability of the structure to remain intact so that explosion propagation, fatalities, and severe injuries will not occur).
- Secondary missiles (hazardous fragments) generated in the occupied areas. Hazardous fragments for fatalities and severe injuries are defined as those having greater than 58 ft-lb impact energy.

Class I Explosives Bays

Bays for Class I (high accident potential) activities shall, in addition to complying with the requirements for Class II Bays, provide protection to prevent serious injuries to all personnel, including personnel performing the activity, personnel in other occupied areas, and all transient personnel. This protection may be achieved by controlling blast and debris through suppression and containment or by establishing an exclusion area with positive access control. Prevention of serious injuries is provided where personnel will not be exposed to:

- Overpressures greater than 5 psi maximal effective pressure and should not exceed 2.3 psi peak positive incident pressure. The 5 psi value is the threshold pressure for eardrum rupture.
- Structural collapse of the building from overpressure or debris impact. Structural collapse is the loss of structural integrity from failure of a structural component as a direct result of the facility’s being subjected to various loadings (judged in accordance with the ability of the structure to remain intact so that explosion propagation and serious injury to personnel will not occur).

- Missiles (hazardous fragments). Hazardous fragments for serious injuries are defined as those having greater than 11 ft-lb impact energy.

1307-4.2.3 Joint Explosives-Plutonium Bays/Facilities

General

Bays for joint explosives-plutonium activities shall comply with the requirements of Section 1307-4.2.2, Explosives-Only Bays-Facilities for Storage, Handling, and Processing, for the class of explosives activity involved and DOE-DNA TP-20-7. Additionally, because of the plutonium contamination potential, they shall comply with the following requirements.

Bays for Uncased Explosives-Plutonium

Where it is necessary to store, handle, or process uncased explosives assemblies in the same bay with plutonium, the enclosing structure and its associated ventilation, electrical, fire protection, and utility systems shall be designed to ensure that in the event that all the explosives detonate the guidelines in Section 1300-1.4.2, Accidental Releases, are not violated. Radiation protection features shall be included to provide worker protection equivalent to that specified for plutonium facilities.

The quantity of plutonium allowed in this bay will be governed by a safety analysis of the specific activities to be conducted therein and the risk to the workers. Activities may be performed in Class IV bays if only IHE, IHE subassemblies, or IHE weapons are present; however, the limit of plutonium allowed will be governed by criticality considerations.

Bays for Cased Explosives-Plutonium Activities

For those bays where it is necessary to conduct operations or to process cased explosive component assemblies that contain plutonium, a Class II-level of protection shall be provided. Storage shall conform to Class III requirements. The limit of plutonium shall be 25 kilograms per bay. The plutonium limits for magazines are specified in DOE/DNA TP-20-7. Activities may be performed in Class IV bays if only IHE, IHE subassemblies, IHE weapons, or test devices are present; however, the limit of plutonium allowed will be governed by criticality considerations.

Staging Bays (in-process)

The practice of using staging bays is permissible as long as the bay(s) is (arc) designed to provide Class II level of protection.

Design for Natural Phenomena

A high level of protection from natural phenomena for HE-Pu bays is required. Bays involving the coincident storage, handling, or processing of HE and plutonium, whether the HE is cased or not, are considered sensitive operations with respect to the potential hazards from high winds, tornadoes, and seismic phenomena. Structures, systems, and associated equipment involved in these activities shall be designed to protect the HE from the loads induced by such forces, including missile loads. The application of these criteria shall not have an adverse effect on the explosion protection design features of the structure. The degree of protection afforded IHE-plutonium bays or explosives-only bays and their support buildings shall be based on a determination of the function housed and its effect on the accomplishment of the mission of the installation. See Section 0111-99.0, Nonreactor Nuclear Facilities-General, for design details for specific natural phenomena. Also see Section 1660-99.4.4, Lightning Protection.

1307-4.2.4 Explosives Design Basis

Blast-resistant design for personnel and facility protection shall be based on the TNT equivalency of the maximum quantity of HE to be used in the bay. For example, based on heat of detonation, one pound of one of the most energetic plastic-bonded explosives is equivalent to 1.3 pounds of TNT. It is recommended by TM 5-1300 that the "effective charge weight" or the "actual charge weight," depending on the method used to determine the TNT equivalent, be increased by 20 percent for design purposes.

For total containment facilities, the internal gas pressure produced in an accident may be the controlling design requirement rather than blast pressure. For internal pressure calculations, the TNT equivalency for blast pressures may not be applicable.

1307-4.2.5 Utilities

The design of utility services for explosives facilities shall provide reliability consistent with operational requirements, value, and potential hazard.

1307-5 DECONTAMINATION AND DECOMMISSIONING

Installations handling explosives and radioactive material shall have a personnel decontamination facility for emergency use. Minimum requirements shall include sinks, showers, and change areas. Provisions shall be made for radiation monitoring equipment to be located in the decontamination room and at specified locations where workers exit from potentially contaminated areas.

1307-6 PHYSICAL PROTECTION AND MATERIAL SAFEGUARDS

Explosives facilities shall comply with the DOE 5632 series. Advice and guidance shall be obtained from cognizant DOE safeguards and security personnel during the planning and design of explosives facilities.

1318 URANIUM ENRICHMENT FACILITIES

1318-1 COVERAGE

Section 1300, General Requirements, shall apply. These requirements are *in addition to* the requirements of that section and other applicable sections of these criteria, particularly those sect ions numbered -99.0, Nonreactor Nuclear Facilities-General.

This section is applicable to facilities that enrich uranium by the gaseous diffusion, gas centrifuge, or AVLIS process. UEFs include

- Storage capability for incoming feed material
- A sampling station
- A feed system
- Equipment for the enrichment process
- A product withdrawl system
- A tails withdrawal system
- Product packaging, storing, and shipping areas
- Cleaning and decontamination areas
- Assembly/disassembly areas
- Maintenance and storage areas
- A central control station
- A complex to provide technical service and administration

These criteria shall apply to all levels of uranium-235 enrichment. The following are three popular assay levels of uranium-235 enrichment:

- Reactor grade assay (2.5 to 5 percent)
- High enrichment assay (5 to 94 percent)
- Very high enrichment assay (above 94 percent)

1318-2 OBJECTIVES

The design objective shall be to ensure that conservatively estimated consequences of normal operations and credible accidents are limited in accordance with the guidelines contained in Section 1300-1.4, Guidance on Limiting Exposure of the Public.

1318-3 NUCLEAR CRITICALITY SAFETY

For low (<4%) uranium-235 enrichment product, a criticality event is unlikely; but shall be considered. For high (>4% but <20%) and very high (>20%) enriched uranium, nuclear criticality safety shall be achieved by favorable geometry, minimization of neutron moderation, and administrative procedures.

Favorable geometry shall be achieved by cylinder/vessel size and shape, by limiting the number of cylinders/vessels that can be stacked in a single array, and by establishing a minimum distance between arrays.

Moderation of neutrons shall be minimized by reducing the quantity of hydrogenous materials.

Process systems shall be designed to prevent the carry-over of fissile material and other material capable of sustaining a chain reaction from geometrically safe portions of the facility to other areas of the facility.

A system of positive control and backflow prevention shall be provided in all process systems to prevent inadvertent transfer of fissile material and other material capable of sustaining a chain reaction from geometrically favorable or poisoned containers to unsafe containers.

1318-4 SPECIAL DESIGN FEATURES

1318-4.1 General

A system design that is not susceptible to the freeze-out or solidification of UF_6 in the gas processing streams or equipment shall be provided.

Special consideration shall be given to the handling of flammable and other hazardous gases and chemicals to minimize their hazard.

Optimum working inventory shall be part of the design for controlling and confining hazardous substances. Optimum working inventory is defined as the minimum feasible inventory considering operational requirements and resulting frequency of material transfer activities. See CONF-86-09116-1 for a risk assessment of hazardous substances that are found in enrichment facilities.

Water from fire sprinkler systems shall be shielded from mixing with UF_6.

Standby power shall be provided automatically on loss of normal power. The standby power system shall be safety class and capable of providing continuous power for the time required to achieve a safe shutdown condition or for the period of time that components require power to perform their necessary safety functions, whichever is greater. The electric power generating capacity shall be the sum of all emergency power loads and provide adequate reserve capacity for future loads. The inductive loads from equipment startup, such as induction motor starts, shall be considered in the standby power system design.

1318-4.2 UF_6 Cylinder Handling Areas

Equipment for handling cylinders shall be designed to ensure:

- A minimum potential for UF_6 release

- Safe operations with cylinders, including storage, movement, receipt, shipment, and sampling

- Strict adherence to the requirements for nuclear criticality safety

Facility design shall include an area for cylinder inspection (internal and external), hydrostatic testing, and repair.

1318-4.3 Sampling, Feed, Conversion, and Preparation Areas

Adequate provisions for cylinder sampling shall be provided for in the design. The normal sampling operation design shall include instrumentation for determining cylinder pressure, autoclaves for heating the cylinders, capability for thorough mixing of the contents, and equipment for vapor and liquid sampling, as appropriate. Cooling of the cylinder (for solidification of UF_6) shall be part of the design for the sampling station.

A sampling area shall be located in or adjacent to the receiving-shipping area of the facility. This area shall be equipped with steam-heated, self-contained autoclaves, special material-handling equipment, and weight measurement scales with automatic time and weight printout to accommodate the DOT-approved 2-1/2-ton, 10-ton, or 14-ton shipping containers. The autoclaves shall be equipped with a sensor system to automatically shut off the steam in case of overheating, cylinder leakage, or cylinder rupture.

The feed preparation area for gaseous diffusion and gas centrifuge facilities shall consist of self-contained autoclaves with appropriate instrumentation and safety systems to control the steam heating of inspected UF_6 cylinders placed in the autoclaves. Autoclave shall be designed to contain the rupture of a uranium cylinder. A sensor system shall sense the release of UF_6 inside the autoclave and shut off the steam and water to the autoclave.

The gas centrifuge process is more sensitive than the gaseous diffusion process to the presence of "light gas" impurities (i.e., air, CO_2, HF, and N_2).The quantity of "light gases" shall be reduced as needed to satisfy the requirements of the centrifuge being used.

For the conversion of UF_6 to feed material for AVLIS facilities, the design of UF_6 reduction towers and surrounding area shall include confinement integrity, hydrogen monitoring, and explosion venting. UF_4 transfer lines shall be designed for complete confinement with consideration given to maintenance operations. The UF_4 transfer system shall be resistant to HF acid. Removal of uranium debris from the reduction vessels shall be performed within ventilated enclosures. If the chosen feed conversion process differs from the concept of UF_6 to UF_4 conversion, then the design criteria for this chosen process shall be consistent with the intent of DOE 6430.1A.

Feed for AVLIS facilities shall be metal billets. The separator feedstock shall be stored in a manner that prevents the dispersion of uranium. The billet fabrication process, starting with the preparation of feed material through the removal of billets from the induction furnace, shall be performed under an inert gas cover. Cleaning and refurbishing of induction furnace graphite crucibles shall be performed within ventilated enclosures.

1318-4.4 Uranium Enrichment Areas

These requirements shall apply to all levels of uranium-235 enrichment. The major areas for design consideration in a gaseous diffusion facility shall be equipment, i.e., compressors, converter, motors, electric power, cooling, instrumentation and controls, piping, purge, and support facilities. The designer shall incorporate the latest improvements for optimum-sized equipment to meet the design requirements and provide high reliability (99+ percent on-stream efficiency). Compressors shall be provided with high temperature sensors and vibration detectors to indicate problems before the equipment is destroyed.

The major areas for design consideration in a gas centrifuge facility include centrifuge machines, electric power, cooling, instrumentation and controls, piping, purge, and support facilities. The design shall incorporate the beat available improvements for optimum sized equipment to meet the design requirements and provide for reliable operations. Centrifuge units shall be equipped with speed sensors to indicate any unusual or undesired change in speed.

The major areas for design consideration in an AVLIS facility shall be laser systems, electric power, AVLIS separator system, cooling, instrumentation and control, protective enclosures, and support facilities. The design shall incorporate the latest improvements for optimum-sized equipment to meet the design requirements and provide for reliable operations.

All high-powered laser light paths in the AVLIS facility shall be designed as enclosed lasers. Interlocks shall be provided on all laser system enclosures.

The AVLIS separator module shall be designed to withstand the design basis molten-metal water reaction (see FAI/83-9). The module wail thickness shall be sufficiently thick to reduce externaI X-ray exposure rates to less than 0.5 mR/h. Additional shielding shall be provided, as required, at module penetrations to eliminate leakage radiation. Separator pods shall be disassembled and cleaned within ventilated enclosures or work areas.

1318-4.5 Products and Tails Processing Areas

At gaseous diffusion and gas centrifuge facilities, the UF_6 gas product shall be withdrawn at the top of the cascade (highest assay stage), condensed, and drained into a DOT-approved shipping container. The equipment necessary to perform this operation shall include the mass spectrometer to analyze the assay sample, equipment for liquefaction or condensing the product stream, filling stations with weighing scales, DOT-approved UF_6 shipping containers, a shipping container handling and transport system, and a cooling area. Transuranic impurities are unwanted in the high assay material and shall be removed by a physical adsorption trapping system. Feed level impurities are acceptable for most reactor grade assay material under 5 percent.

At gaseous diffusion and gas centrifuge facilities, the equipment required for the tails processing shall be similar to the equipment required for product processing, but larger in size and volume-handling capacity. Stream impurities and favorable geometry containers are not a design consideration for the tails processing.

Product conversion in AVLIS facilities shall be designed to meet performance and nuclear criticality safety including favorable geometry requirements Tails ingots shall be packaged and stored in a manner that will minimize the formation and dispersion of uranium oxide.

1318-5 CONFINEMENT SYSTEMS

1318-5.1 General

The actual confinement system requirements for a specific UEF shall be determined on a case-by-case basis.

Generally, UEFs use two confinement systems. The primary confinement system consists of the process system pressure boundary and its purge and off-gas connections. The secondary confinement system is the barriers that enclose the areas in which the process system components are located and includes the associated system that ventilates the enclosed areas. The degree of confinement required for UF_6 will generally depend on the physical state of the UF_6 (eg., solid, liquid, or gas).

1318-5.2 Primary Confinement System

The primary confinement is the process system pressure boundary and its associated purge and off-gas systems.

The integrity of the primary confinement shall be ensured for all normal operations and anticipated operational occurrences such as loss of electric power, loss of cooling, and loss of instrument and control air, and for the DBAs it is required to withstand.

1318-5.3 Secondary Confinement System

The secondary confinement system consists of the barriers that enclose the areas in which the process system components are located and the associated ventilation system that ventilates the enclosed areas.

The secondary confinement system shall remain functional for all normal operations, anticipated operational occurrences, and the DBAs it is required to withstand.

The secondary confinement barriers shall be designed and located to allow access to all sides of enclosed equipment to facilitate equipment maintenance, inspection, installation, and removal. As required, access panels shall be provided to allow operation and observation of equipment inside an enclosed area by personnel outside the enclosure. The secondary confinement areas shall be equipped with sensors to detect releases of UF_6 from the primary confinement boundary and provide appropriate alarms.

Penetrations of the secondary confinement barriers shall be minimized. To the extent practical, all equipment components not functionally required to operate directly in the presence of the UF_6 shall be located outside the secondary confinement. The design of equipment that must be located within the secondary confinement area shall, to the extent practical, allow for in-place maintenance and/or replacement. Penetrations of the secondary confinement barriers shall have positive seals to prevent the migration of contamination out of the confinement area if there is a failure of the process system or primary confinement.

Each secondary confinement area shall be supplied ventilation air from the building ventilation system. The area shall be provided with exhaust ventilation with sufficient capacity to ensure an adequately controlled ventilation flow as required in the event of a credible breach in the secondary confinement barrier. Pressure in the compartments shall be negative with respect to the building ventilation system.

1318-6 EFFLUENT CONTROL AND MONITORING

1318-6.1 Radioactive Solid Waste

The solid radioactive waste typically associated with a UEF that shall be considered during the design include but are not limited to uranium contaminated waste such as alumina and other traps, classified waste (e.g., barrier materials, failed centrifuge parts), and nonuranium contaminated waste. Nuclear criticality safety shall be considered in the design of the radioactive solid waste processing facility.

The major waste-handling problem will be an excess of fluorides in solids and solutions. Design considerations shall be given for methods that maximize recovery and recycle of the fluorides. Any remaining fluoride in solid waste that is to be permanently disposed of shall be immobilized.

1318-6.2 Radioactive Liquid Waste

1318-6.2.1 Process Wastes

The liquid radioactive wastes typically associated with a UEF that shall be considered during the design include but are not limited to liquid decontamination and cleaning waste and contaminated laundry wastes. Nuclear criticality safety shall be considered in the design of the liquid radioactive waste processing facility.

1318-6.3 Effluents

1318-6.3.1 Airborne Effluents

The airborne radioactive wastes typically associated with a UEF that shall be considered during the design include but are not limited to contaminants in the purge cascade vent system such as UF_6 and contaminants in other process vent streams (e.g., cold recovery, buffer seal exhaust). Nuclear criticality safety shall be considered in the design of the airborne effluent system.

All exhaust outlets that may contain uranium contamination shall be provided with two monitoring systems. These monitoring systems shall comply with Section 1589-99.0.1, Radioactive Airborne Effluents.

1318-7 STORAGE FACILITIES

Stacking requirements for cylinder storage arrays and separation distances between arrays shall be determined before preliminary design has begun. The criterion for determination of these parameters shall be criticality prevention and shall be considered based on the greatest enrichment expected to be present in a given array.

Separate storage areas shall be provided for "feed" cylinders, "product" cylinders, and "tails" cylinders. In addition, different storage areas shall be provided for products with differing enrichment assays.

UF_6 shall be stored and transported in DOT-approved containers. Other toxic substances shall be contained, stored, and transported in containers that are standard for the chemical industry.

The design professional shall consider the criteria provided in USNRC R.G. 3.13 for applicability to UEFs.

1319 URANIUM PROCESSING AND HANDLING FACILITIES

1319-1 COVERAGE

Section 1300 General Requirements, shall apply. These requirements are *in addition to* the requirements of that section and other applicable sections of these criteria, particularly those sections numbered -99.0, Nonreactor Nuclear Facilities-General.

A UPHF is a facility that receives feed material from sources such as a conversion facility, a reprocessing facility, or fuel/target storage material. It processes, handles, and produces products such as UO_2, UF_6, uranium metal, reactor fuel assemblies, target assemblies, and nuclear weapons components.

This section is not process specific. It is applicable to facilities that handle and process uranium; however, it is principally directed at facilities that process and handle uranium enriched in U-235.

1319-2 OBJECTIVES

The design objective shall be to ensure that conservatively estimated consequences of normal operations and credible accidents are limited in accordance with the guidelines contained in Section 1300-1.4, Guidance on Limiting Exposure of the Public.

1319-3 NUCLEAR CRITICALITY SAFETY

Nuclear criticality safety shall be controlled, in decreasing priority, by geometric spacing, density and/or mass limitation, fried neutron absorbers, soluble neutron absorbers, and administrative control.

Enclosures and material transport and transfer systems shall be designed so that enriched uranium and moderating material in excess of safety limits cannot be added to otherwise criticality-safe enclosures or areas.

Process systems shall be designed to prevent the carry-over of fissile material and other material capable of sustaining a chain reaction from geometrically favorable portions of the facility to other areas of the facility.

A system of positive control and backflow prevention, such as air gaps (siphon breakers), shall be designed to prevent the inadvertent transfer of fissile material and other material capable of sustaining a chain reaction from geometrically favorable or poisoned containers to unsafe containers.

Process enclosure floor drains shall be designed to preclude the accumulation of fissile material and other material capable of sustaining a chain reaction in associated traps and piping.

The design professional shall consider the criteria provided in R.G. 3.34 for applicability to UPHFs.

1319-4 SPECIAL DESIGN FEATURES

Materials of different uranium assays shall be handled in physically different trains of equipment even though duplication of equipment results. If this is not possible, the equipment shall be sized for criticality control of the most restrictive condition.

A definite isotopic specification for reactor returns shall be established before facility design is started for refabrication of enriched uranium that has been irradiated and reprocessed.

Metallurgical processes and ceramic materials processing are the two principal types of processes for fabrication of uranium products. The hazards associated with each of these processes shall be considered during the design of the fire protection, ventilation, and confinement systems. In addition, the chemical toxicity of uranium shall be considered during the design of the facility. The design shall provide specific control and isolation of flammable, toxic, and explosive gases, chemicals, and materials admitted to the areas of the facility.

The design shall provide space for shielding, both permanent and temporary, for personnel and/or remote operations of equipment and processes.

The primary confinement system shall be constructed of fire-resistant materials, and the process equipment and process being confined shall be designed to prevent or minimize the probability of potential flammable or explosive conditions. Confinement enclosures for flammable metals shall be designed with self-contained fire protection and extinguishing equipment; in some cases, inert atmospheres may be desirable within the enclosures.

The design professional shall ensure that all work that could subject personnel to possible inhalation exposures is performed in process confinement enclosures by using appropriate designs. Glove boxes shall be the preferred enclosure.

When glove boxes are used, their design and construction shall allow replacement of parts and/or relocation of the box(es) within the facility or system(s) with a minimum of contamination (see Section 1161, Enclosures).

To the extent practical, discrete processing steps shall be performed in individual process confinements to reduce the amount of hazardous material capable of being released by a single or local failure of the confinement system.

Process and auxiliary system differential pressure shall be maintained to inhibit backflow of hazardous materials into auxiliary systems.

All process operations that involve oxide powder or that can generate powder or dust shall be provided with special confinement to prevent contamination spread. Facility design shall preclude the handling of uranium oxides in large open rooms.

When inert confinement system atmospheres are used, consideration shall be given to the treatment by purification and moisture removal systems of the inert atmospheres to allow their recirculation.

Small-volume process enclosures shall be designed to prevent the enclosed atmosphere from being pressurized by rapid insertion of gloves into the enclosure.

Equipment design shall facilitate decontamination and appropriate interlocks to prevent spills and cross-contamination.

Installed (fixed) airborne radioactivity monitors shall have a minimum sensitivity of 8 DAC-hours.

Safeguards ability should be considered in the selection of the preferred processing alternative. Factors such as location of the facility, material holdup, vulnerability to diversion, and ease of inventory must be evaluated.

1319-5 CONFINEMENT SYSTEMS

1319-5.1 General

The following provisions are typical for a UPHF confinement system. The actual confinement system requirements for a specific UPHF shall be determined on a case-by-case basis.

Generally, facilities that process and handle unirradiated enriched uranium use two confinement systems. The primary confinement system encloses or confines the uranium materials being fabricated and the equipment used to process the uranium. The secondary confinement consists of the structures and associated ventilation systems that surround the operating areas that house the primary confinement system. The secondary confinement system barriers are those that separate the outside environment and free access areas, such as offices and lunch rooms, from potential contamination.

1319-5.2 Primary Confinement System

The primary confinement system includes barriers, enclosures (including their associated ventilation or atmosphere control systems), and process piping and vessels. Its principal function is to prevent the release of hazardous substances into the operating areas.

The integrity of the primary confinement system shall be ensured for all normal operations, anticipated operational occurrences, and for the DBAs it is required to withstand. Breaches of the primary confinement barrier (e.g., due to glove or seal failure) are acceptable if the off-gas treatment system is capable of maintaining an adequate inflow of air for the specified breach size and location. Some portions of the primary confinement may not form a complete physical enclosure. For these, the primary confinement function shall be ensured by adequate air flow and appropriate process equipment design.

If needed, conveyors shall be used to interconnect glove boxes or other primary confinement enclosures to minimize introduction and removal of materials from the system. The primary confinement system criteria shall be applied to these interconnections.

Special design features shall be considered to ensure safe introduction and removal of materials from process confinements.

All process vessels that amid contain uranium shall vent to the process off-gas system, which, in turn, shall pass through pretreatment, if needed, and HEPA filtration.

Three types of metallurgical processes require special ventilation considerations:

- Processes that use volatile or easily entrained organic liquids
- Processes that produce either finely divided particles of metal or small metal chips
- Processes that use corrosive chemicals (e.g., acids, perchlorates)

The first type of process shall have ventilation that provides sufficient air movement around the process area to prevent exposure of personnel to the hazardous liquid or vapor. The design shall incorporate roughing filters and/or other types of traps to remove entrained organic liquid droplets from the process off-gas before the off-gas enters the main ventilation ducting to prevent ventilation ducts from becoming coated with the organic, and thus, creating a fire hazard.

The second type of process shall have the same kind of front-end ventilation adaptations as for hazardous vapors and liquids to prevent metal accumulations in the off-gas ducting or in the final filtration train(s). Roughing filters or centrifugal separators may be sufficient to remove metal particles from the off-gas.

The third type of process shall use off-gas scrubbers to preclude the possibility of damage to the exhaust air cleaning system (e.g., HEPA filtration train).

Metallurgical processing equipment shall have dedicated ventilation systems that exhaust to a common, final filtration train. If airborne particle capture is required, a high linear velocity will be necessary to ventilate these process areas due to the greater densities of metal particles.

Ceramic processes involve oxide powder that is finely divided The exposure of personnel to the powder inhalation hazard shall be prevented. Even processes that handle bulk ceramics such as pellets are not dust-free operations, and thus, adequate ventilation shall be required.

1319-5.3 Secondary Confinement System

The secondary confinement system generally consists of the confinement barriers and associated ventilation systems that surround or confine the operating areas that house the process system and its primary confinement.

The secondary confinement system shall remain functional during normal operations and anticipated operational occurrences, and during and following the DBAs it is required to withstand.

The operating area compartments shall have sensors to detect releases of hazardous materials from the primary confinement system and provide appropriate alarms. Commensurate with the potential hazard, consideration shall be given to the use of redundant sensors.

Penetrations of the operating area confinement barriers shall be minimized. When practical, all equipment components not functionally required to operate directly in the presence of radioactive materials shall be located outside the operating area compartments. All penetrations of the secondary confinement shall have positive seals to prevent the migration of contamination out of the operating area.

Each secondary confinement compartment shall be supplied with ventilation air from the building ventilation system and shall have exhaust ventilation with sufficient capacity to ensure an adequately controlled ventilation flow as required in the event of a credible breach in the operating compartment confinement barrier. Pressure in the compartments shall be negative with respect to the building ventilation system.

1319-6 EFFLUENT CONTROL AND MONITORING

1319-6.1 Radioactive Solid Waste

The solid radioactive wastes typically associated with UPHFs that shall be considered during the design include but are not limited to uranium, uranium-contaminated solid waste and nonrecoverable scrap (e.g., prefilters, HEPA filters, used gloves). In addition, there will be general process trash (e.g., waste, paper, plastic bags). Nuclear criticality safety shall be considered in the design of the radioactive solid waste processing facility.

1319-6.2 Radioactive Liquid Waste

The liquid radioactive wastes typically associated with UPHFs that shall be considered during the design include but are not limited to uranium-contaminated liquid waste and nonrecoverable scrap (e.g., liquid filter sludge, wet grinding effluent, contaminated solvents, contaminated oil), and contaminated laundry waste. Nuclear criticality safety shall be considered in the design of the liquid radioactive waste processing facility.

1319-6.3 Effluents

1319-6.3.1 Airborne Effluents

The airborne radioactive wastes typically associated with UPHFs that shall be considered during the design include but are not limited to airborne particulate material generated by fabrication processes (e.g., airborne grinding dust). Nuclear criticality safety shall be considered in the design of the airborne effluent system.

All exhaust outlets that may contain uranium contamination shall be provided with two monitoring systems. These monitoring systems shall be comply with Section 1589-99.0.1, Radioactive Airborne Effluent.

1319-7 DECONTAMINATION AND DECOMMISSIONING

The UPHF design shall include a special, permanent decontamination process capability in a dedicated area that is furnished with the appropriate equipment and utilities for decontamination of tools and equipment.

1319-8 STORAGE FACILITIES

Storage of enriched uranium shall comply with the storage requirements of Section 1306, Unirradiated Enriched Uranium Storage Facilities.

1320 IRRADIATED FISSILE MATERIAL STORAGE FACILITIES

1320-l COVERAGE

Section 1300, General Requirements, shall apply. These requirements are *in addition to* the requirements of that section and other applicable sections of these criteria, particularly those sections numbered -99.0, Nonreactor Nuclear Facilities-General.

IFMSFs are self-contained installations for storage of highly radioactive fissile material (e.g., spent fuel and target elements) that has been exposed to a neutron fluence usually in a nuclear reactor. The irradiated material is properly clad or canned when received such that leakage from the assemblies is minimized and remains within specified limits. The IFMSF stores the material in a manner that ensures the integrity of the cladding or canning. The stored material is shipped to facilities such as a reprocessing facility, hot laboratory, or high-level solid radioactive waste facility.

This section applies to a water pool type or dry type of storage facility. Spent fuel storage facilities that are part of a reactor facility are not covered by this section. They are covered by DOE 5480.6.

These criteria shall be applied in the planning and design of new or modification of existing IFMSFs to contain IFM. They do not apply to in-process or in-use materials.

1320-2 OBJECTIVES

The design objective shall be to ensure that conservatively estimated consequences of normal operations and credible accidents are limited in accordance with the guidelines contained in Section 1300-1.4, Guidance on Limiting Exposure of the Public.

1320-3 NUCLEAR CRITICALITY SAFETY

Favorable geometry, as implemented by storage rack design, is the preferred method of implementing nuclear criticality safety. When fixed neutron absorbers are used, the rack design shall include provisions to verify the absorber's continual efficacy and to prevent their inadvertent removal by mechanical or chemical action. Storage racks shall be designed as safety class items and shall their integrity during and following a DBA.

1320-4 SPECIAL DESIGN FEATURES

To ensure that adequate water is available to cool and shield the stored IFM, the pool shall be designed as a safety class structure and structural integrity ensured following a DBE.

The coding waler system for a water pool type IFMSF shall perform its required functions during normal and anticipated operating conditions, and shall be capable of limiting the maximum pool temperature to 110°F.

For a water pool type facility, the cooling water system shall be designed as a safety class system unless there is a safety class emergency source of makeup water for the storage pool and it can be demonstrated that, under emergency conditions, the pool structure can withstand the stresses imposed by the loss of cooling (i.e., boiling of pool water) and the integrity of the stored IFM is not affected. If the emergency makeup system is not permanently installed, the time required to implement its operation shall be less than the time required to lower the pool water level to the minimum allowable depth or raise the pool temperature to boiling.

A pool water cleanup system shall be provided to maintain water clarity, ensure long-term cladding integrity, ensure structural integrity of the storage racks and other submerged structures, and maintain exposure rates and airborne contamination levels on the operating floor within the guidelines specified in DOE 5480.11. In addition, to the extent practical, the design of this system shall use ALARA principles to minimize overall exposures and contamination levels.

The piping configuration for the pool cooling water and cleanup system shall be designed to eliminate the possibility of siphoning the pool water to a level below the minimum depth required for shielding and/or cooling.

To the extent practicable, passive cooling means shall be used at dry type storage facilities. If a cooling water jacket or air system is provided to ensure an acceptable temperature of the stored material within the dry type storage facility, it shall be designed as a safety class system.

The design professional shall consider the following:

- Filters capable of being either remotely backflushed or designed so that cartridges can be removed directly into a shielded container

- Instrumentation for periodic functional testing of the pool water cleanup system performance

- Instrumentation for periodic functional testing of the heat exchanger(s).

A system shall be incorporated into the design that can detect leakage from stored IFM in the event of a cladding or canning failure that could allow the escape of fission products and other radioactive material greater than specified limits. This system shall include the following:

- The system shall allow for the sampling of coolant such that an individual leaking assembly can be identified.

- System components, piping, and instrumentation shall be appropriately shielded to maintain operator exposures within the guidelines specified in DOE 5480.11 and shall use ALARA design principles to minimize overall exposures.

- The storage facility shall contain provisions that allow the temporary storage of a leaky assembly. These provisions shall limit the spread of contamination by a leaky assembly and provide adequate cooling and shielding of the assembly.

- The design professional of the IFMSF shall consider provisions that allow for the interim canning of leaking assemblies until disposal.

The design professional shall consider the criteria provided in 10 CFR 72 and the following guides for applicability to IFMSFs:

- R.G. 3.49

- R.G. 3.54

1320-5 CONFINEMENT SYSTEMS

1320-5.1 General

The following provisions are typical for a IFMSF confinement system. The actual confinement system requirements for a specific IFMSF shall be determined on a case-by-case basis.

In general, the primary confinement shall be the IFM cladding or canning. Secondary confinement shall be established by the facility buildings that enclose the dry storage area and/or the storage pool and auxiliary systems.

1320-5.2 Primary Confinement System

The IFM cladding or cans, as appropriate, shall provide primary confinement during normal and anticipated operational occurrences.

The IFM cladding or canning shall be designed to provide a corrosion-resistant confinement for the IFM material to prevent an uncontrolled release of radioactive material.

Special design features shall be considered to ensure safe loading, removal, and handling of IFM. These systems and equipment shall be designed as safety class items and shall protect against the dropping of shipping casks, IFM assemblies, and other items on the stored IFM. In water pool type facilities, damage to the pool during loading and unloading operations shall not allow the pool level to drop below the minimum allowable depth. Consideration shall be given to features that will prevent breaching the pool integrity if a shipping cask is dropped.

1320-5.3 Secondary Confinement System

The facility building and ventilation make up the secondary confinement system.

The secondary confinement system shall be designed to function during normal operations and anticipated operational occurrences. It shall also be capable of performing its necessary safety functions during and following the DBAs it is required to withstand.

Penetrations of the secondary confinement barrier shall have positive seals to prevent the migration of contamination. The use of positive seals shall be considered for penetration of enclosures within the facility building to ensure the proper ventilation flow paths and prevent the uncontrolled migration of contamination.

Ventilation systems shall provide for inlet air filtration (roughing filters) for the main storage building to prevent dust accumulation, thus reducing the load on other filters in the facility. Recirculated air in the main storage building shall be filtered through a HEPA filter to reduce the buildup of radioactive material in the air. Areas with higher potential airborne radioactive contamination (e.g., pool water purification and waste treatment system areas) shall use only once-through air flow. Supply air to these facilities shall be drawn from the main storage building if such design is feasible. Exhaust air shall be HEPA filtered prior to release. lf safety analysis indicates that the guidelines specified in Section 1300-1.4.2, Accidental Releases, could credibly be violated due to a release of radioiodine from a DBA.

1320-7 DECONTAMINATION AND DECOMMISSIONING

Decommissioning of the IFMSF is of utmost importance. The facility design shall include features that will facilitate decontamination for future decommissioning.

For water pool type facilities, the design professional shall consider providing the pool liner with a leakage collection system that will allow leakage detection and limit absorption of contaminated pool water by concrete structures.

1321 REPROCESSING FACILITIES

1321-1 COVERAGE

Section 1300, General Requirements, shall apply. These requirements are *in addition to* the requirements of that section and other applicable sections of these criteria, particularly those sections numbered -99.0, Nonreactor Nuclear Facilities-General.

A reprocessing facility recovers uranium, plutonium, and other selected actinides, and selected fission products from irradiated fissile fuel material and target material, and separates them from each other and from any remaining actinides and fission products.

1321-2 OBJECTIVES

The design objective shall be to ensure that conservatively estimated consequences of normal operations and credible accidents are limited in accordance with the guidelines contained in Section 1300-1.4, Guidance on Limiting Exposure of the Public.

1321-3 NUCLEAR CRITICALITY SAFETY

Process systems shall be designed to prevent the carry-over of sludges, fines, or precipitates of fissile material and other material capable of sustaining a chain reaction from geometrically favorable portions of the facility to other areas of the facility (e.g., from a uranyl nitrate concentrator to the acid recovery system).

A system of positive control and backflow prevention, such as air gaps (siphon breakers), shall be provided to prevent inadvertent transfer of fissile materials and other material capable of sustaining a chain reaction from geometrically favorable or poisoned containers to unsafe containers.

Heating or cooling jackets in the favorable dimension of geometrically favorable vessels shall be incorporated into the design to preclude a leak in the jacket causing an unacceptable reduction of the margin of subcriticality.

Sumps shall be designed so that nuclear criticality safety is ensured if a credible mechanism exists for accumulating fissile material or other material capable of sustaining a chain reaction (e.g., due to leakage from or failure of the primary confinement boundary).

Structures, systems, and components whose failure could in any way result in a criticality shall be designed as safety class items and shall be capable of providing their function following a DBE.

The design professional shall consider the criteria provided in R.G. 3.33 for applicability to reprocessing facilities.

1321-4 SPECIAL DESIGN FEATURES

Process system and auxiliary system differential pressure shall be maintained to inhibit backflow of contamination into auxiliary systems.

The process equipment for transferring toxic and corrosive fluids shall use vacuum and gravity where possible. Pumps and jets shall have pressure capacity no greater than 10 percent above needed transfer capacity.

The integrity of process equipment off-gas treatment systems shall be ensured for normal operations, anticipated operational occurrences, and the DBAs they are required to withstand.

The use of directed airflow and backflow preventers to feed areas (i.e., shear and dissolver areas) is required.

Mechanical chopper and dissolver off-gas and other process vents shall be treated by an off-gas treatment system for removal of nuclides. As a minimum, the treatment system shall be designed for particulate removal and shall control the release of airborne radionuclides to the extent that the guidelines referenced in Section 1300-1.4.3, Routine Releases, are not exceeded. In addition, the design shall incorporate ALARA concepts to minimize impacts on operators and the public/environment.

Radioiodine adsorber units in the exhaust ventilation/off-gas system are required to reduce the radioiodine concentration in the effluent to the extent that the guidelines specified in the references. listed in Section 1300-1.4.3, Routine Releases, are not exceeded. Additionally, these releases shall be ALARA. Acceptable criteria for the design of these units are found in ERDA 76-21.

To reduce the amount of hazardous material capable of being released by a single or local failure of the process equipment, the following design provisions shall be considered:

- Grouping or compartmentalizing process equipment to form units that can isolate the process inventory into modular units

- Provisions for the capability to detect leakage from process equipment

- Selection of the method (e.g., manual, remote-manual, or automatic) of performing corrective actions (e.g., process shutdown) according to the potential hazards associated with a particular release

Design features that shall be considered to ensure maintenance of the principal confinement systems include the following:

- The use of electrical equipment that precludes or minimizes the introduction of an ignition source in flammable or potentially flammable locations

- Measures to ensure that operation of support and protection systems such as a fire protection system do not promote the failure of the principal confinement systems

- Provisions for sprinklers, water fog, or other suitable systems within the secondary confinement to provide for rapid heat removal and minimum pressurization of the process cell or canyon and to minimize the loading of ventilation system filters with combustion products

Process equipment shall be designed to operate under process conditions that prevent or minimize the probability of potentially explosive chemical reactions (e.g., solvent vapor explosions, nitrate-solvent reactions).

Process system design shall include provisions for all fission product oxidation states expected during processing (e.g., suppression of the volatilization of ruthenium, the prevention of iodate formation).

Systems shall be provided to minimize the probability and consequences of pressurizing a primary confinement component as a result of an anticipated operational occurrence or DBA.

The design professional shall consider the criteria provided in the following USNRC Regulatory Guides for applicability to reprocessing facilities:

- R.G. 3.14

- R.G. 3.17

- R.G. 3.20

- R.G. 3.22

- R.G. 3.27

1321-5 CONFINEMENT SYSTEMS

1321-5.1 General

The following provisions are typical for a reprocessing facility confinement system. The actual confinement system requirements for a specific reprocessing system shall be determined on a case-by-case basis.

The degree of confinement required in various locations of the facility depends on the potential hazards associated with the process being carried out and shall suit the most restrictive case anticipated. Consideration shall be given to the characteristics of the hazardous material involved such as type, quantities, physical and chemical forms, dispersibility, and energy available for dispersion.

In general, for the most restrictive case anticipated, the use of three confinement systems shall be considered. In reprocessing facilities where the processes require the use of corrosive or noxious materials, the process system shall be totally enclosed and provided with its own vent system and off-gas cleanup system. In such cases, the process system shall be treated as the primary confinement system. Secondary confinement shall be the process cells and their ventilation system. The tertiary or final confinement shall be the building structure and its ventilation system. In addition to these principal confinement systems, features such as change rooms and special access ways shall be used to minimize the spread of contamination within the facility.

The effectiveness of each confinement barrier shall be checked analytically against all challenges it is expected to withstand without loss of function. This applies to any form of the hazardous material (gas, liquid, or solid) and its carrying medium (i.e., airborne or spilled in a liquid).

In addition, the design professional shall consider the criteria provided in the following guides for applicability to reprocessing facilities:

- R.G. 3.18
- R.G. 3.32

1321-5.2 Primary Confinement System

The primary confinement system consists of process systems equipment and its associated off-gas system.

The integrity of the primary confinement system shall be ensured for all normal operations, anticipated operational occurrences, and for the DBAs it is required to withstand.

Failures of process equipment shall not cause failure of the secondary confinement system.

The process equipment shall be designed to operate under process conditions that prevent or minimize the probability of potential explosive chemical reactions.

1321-5.3 Secondary Confinement System

The secondary confinement system consists of the process cell barriers and the ventilation systems associated with the cells.

The secondary confinement shall be designed to remain functional during normal operations and anticipated operational occurrences. It shall be capable of performing its necessary safety functions during and following the DBAs it is required to withstand.

Secondary confinement areas shall be equipped with sensors to detect abnormal releases of hazardous material from the primary confinement boundary and provide appropriate alarms. Commensurate with the potential hazard, consideration shall be given to the use of redundant sensors.

All penetrations of the secondary confinement shall have positive seals to prevent the migration of contamination out of the secondary confinement area.

The ventilation system shall be designed to maintain a negative differential pressure during the removal of cell covers and for normal in-leakage at cell cover joints.

Process cells shall be supplied ventilation air from the building ventilation system, and shall have exhaust ventilation with sufficient capacity to ensure an adequate controlled ventilation flow as required in the event of a credible breach in the secondary confinement barrier. Pressure in the compartments shall be negative with respect to the building ventilation system. Special features (e.g., air locks, enclosed vestibules) shall be considered for access through secondary and tertiary confinement barriers.

1321-5.4 Tertiary Confinement System

1321-5.4.1 General

The process building and associated ventilation system compose the tertiary confinement system.

The tertiary confinement system shall be designed to function during normal operations and anticipated operational occurrences. It shall be capable of performing its necessary functions during and following the DBAs it is required to withstand.

The tertiary confinement shall be designed to ensure that it can withstand the effects of severe natural phenomena and man-made events, including the postulated DBAs and DBF initiated by those events, and remain functional to the extent that guidelines in Section 1300-1.4.2, Accidental Releases, are not violated.

1321-5.4.2 Penetrations

Penetrations of the building confinement barriers shall have positive seals to prevent the migration of contamination.

1321-6 EFFLUENT CONTROL AND MONITORING

1321-6.1 Radioactive Solid Waste

The solid hazardous wastes typically associated with reprocessing facilities that shall be considered during the design include but are not limited to fuel cladding hulls, iodine adsorber waste (e.g., charcoal, silver zeolite), filter media, nontransuranic waste (e.g., waste dryer solids, nonfuel bearing components), and general trash (e.g., paper, rags, gloves). Nuclear criticality safety shall be considered in the design of the solid radioactive waste processing facility.

1321-6.2 Radioactive Liquid Waste

1321-6.2.1 Process Wastes

The liquid hazardous wastes typically associated with reprocessing facilities that shall be considered during the design include but are not limited to first-cycle co-decontamination waste, concentrated second- and third-cycles waste, general concentrator bottoms, iodine scrubber waste (e.g., sodium hydroxide, silver nitrate) and contaminated laundry waste. Nuclear criticality safety shall be considered in the design of the liquid radioactive waste processing facility.

1321-6.3 Effluents

1321-6.3.1 Airborne Effluents

The airborne radioactive effluents typically associated with reprocessing facilities that shall be considered during the design include but are not limited to dissolver off-gas, process vessel vents, and high-level liquid radioactive waste collection and storage tank vents. Effluent system designs shall preclude the holdup or collection of fissile material and other material capable of sustaining a chain reaction in pinions of the system that are not geometrically favorable. Nuclear criticality safety shall be considered in the design of airborne radioactive effluent systems.

All exhaust outlets that may contain transuranics or fission products shall be provided with two monitoring systems. These monitoring systems shall comply with Section 1589-99.0.1, Radioactive Airborne Effluents.

1321-7 DECONTAMINATION AND DECOMMISSIONING

The facility shall include a special, permanent decontamination process capability in a dedicated area that has the appropriate equipment and utilities for decontamination of all or as much equipment as practical.

1322 URANIUM CONVERSION AND RECOVERY FACILITIES

1322-1 COVERAGE

Section 1300, General Requirements, shall apply. These requirements are *in addition to* the requirements of that section and other applicable sections of these criteria, particularly those sections numbered -99.0, Nonreactor Nuclear Facilities-General.

Uranium conversion facilities receive feed materials such as UF_6, uranyl nitrate or UO_3, process these materials chemically and produce uranium metal, UO^2 and UF_6. Uranium recovery facilities receive and handle scrap feed materials that are of different types, shapes, sizes, uranium contents, and enrichments. The kind of scrap and therefore the process to facilitate recovery of uranium may vary as frequently as daily. This section is not process-specific. It is principally directed at facilities that produce products that arc feed materials for uranium processing and handling facilities and those facilities that receive scrap from uranium process and handling facilities for the purpose of recovering the uranium.

1322-2 OBJECTIVES

The design objective shall be to ensure that conservatively estimated consequences of normal operations and credible accidents are limited in accordance with the guidelines contained in Section 1300-1.4, Guidance on Limiting Exposure of the Public.

1322-3 NUCLEAR CRITICALITY SAFETY

Enclosures and material transport and transfer systems shall be designed so that enriched uranium and moderating material in excess of posted limits cannot be added to these enclosures or areas.

Process systems shall be designed to minimize the carry-over of fissile material and other material capable of sustaining a chain reaction from geometrically favorable portions of the UCRF to other areas of the UCRF.

A system of positive control and backflow prevention, such as air gaps (siphon breakers), to prevent inadvertent transfer of fissile material and other material capable of sustaining a chain reaction from geometrically favorable or poisoned containers to unsafe containers shall be included.

Process enclosure floor drains shall be designed to preclude the accumulation of fissile material and other material capable of sustaining a chain reaction in associated traps and piping.

For uranium conversion facilities and UF_6 feed cylinders containing low enriched uranium, a criticality event is unlikely, but shall be considered. For high enriched uranium, nuclear criticality safety provisions shall be achieved by favorable geometry and minimization of neutron moderation. Favorable geometry shall be achieved by cylinder/vessel size and shape, limiting the number of cylinders/vessels that can be stacked in a single array, and establishing a minimum distance between arrays.

Nuclear criticality safety geometric restrictions shall be the major consideration in the design of the principal processing equipment units.

For a uranium recovery facility, nuclear criticality safety control is more complex because of the variety of materials and greater range of both uranium concentration and total mass of uranium that can be contained in the scrap. Therefore, administrative controls must be implemented to augment the limitations of design controls.

The design professional shall consider the criteria provided in R.G. 3.34 for applicability to UCRFs.

1322-4 SPECIAL DESIGN FEATURES

1322-4.1 General

The design shall provide special control and isolation of flammable, toxic, and explosive gases, chemicals, and materials admitted to the areas of the facility.

To the extent practical, the primary confinement system shall be constructed of fire-resistant materials, and the process equipment and process being confined shall be designed to prevent or minimize the probability of potential flammable or explosive conditions. Confinement enclosures for flammable metals shall be designed with self-contained fire protection and extinguishing equipment; in some eases, inert atmospheres may be desirable within the enclosures.

The design shall ensure that all work that could subject personnel to possible inhalation exposures is performed in process confinement enclosures. Glove boxes shall be the preferred enclosure, but are not always practical. Alternative systems may have to be considered.

When glove boxes are used, their design and construction shall be such as to allow replacement of parts and/or relocation of the box(es) within the facility or system(s) with a minimum of contamination or exposure.

To the extent practical, discrete processing steps shall be performed in individual process confinements to reduce the amount of hazardous material capable of being released by a single or local failure of the confinement system.

Process and auxiliary system differential pressure shall be maintained to inhibit backflow of hazardous materials into auxiliary systems.

Equipment design shall facilitate decontamination and shall include appropriate interlocks to prevent spills and cross-contamination.

The design of process systems shall minimize the production of scrap and waste.

Commercially available, standard equipment with necessary modifications shall be used whenever possible.

Geometric restrictions for nuclear criticality safety shall be applicable to various units of equipment for the different processes used. In addition, other considerations such as provision for sufficient agitation in a process vessel to prevent uranium material from settling out shall be considered for nuclear criticality safety.

Leakage of enriched uranium material from processing equipment shall be prevented. Design considerations shall include, but not be limited to, the use of corrosion-resistant materials of construction and features less vulnerable to leakage, e.g., of flanged and/or welded construction.

Use of thermal insulation on the equipment that processes uranium solutions of high enrichment shall be minimized because it absorbs the solution in the event a leak occurs. The uranium-impregnated insulation would be subject to scrap recovery operations. Because the insulation is considered as a "full reflector," the equipment together with the insulation may not be geometrically favorable for highly enriched uranium solutions.

Storage tanks for aqueous solution of enriched uranium shall be designed to ensure favorable geometry with respect to nuclear criticality safety. Where there is a tendency for solids to precipitate, vessels shall be instrumented to detect settling of solids and be designed to facilitate periodic removal of solids.

1322-4.2 Uranium Conversion Facilities

Piping systems, surge vessels, and control instruments with associated piping that carry UF_6 gas shall be equipped with heat tracing or heated enclosures wherever necessary to prevent solidification of UF_6. Steam may be used as the primary heating agent where low-enrichment material (less than or equal to 2 percent uranium-235) is involved. At higher enrichments, a dry radiant heat source shall be the preferred means of supplying the heating requirements.

1322-4.3 Uranium Recovery Facilities

The design of a uranium recovery facility shall be approached on a case-by-case basis, and shall consider all possible forms of scrap and different assays of material that could be received for processing and all possible methods that could be used for enriched uranium recovery.

Materials of different uranium assays shall be handled in physically different trains of equipment even though duplication of equipment results. If this is not possible, the equipment shall be sized for criticality control of the greatest uranium enrichment.

For enriched uranium that has been irradiated and reprocessed a definitive isotopic specification for the uranium shall be adopted before facility design is begun.

In addition to provisions for handling uranium and other radioactive materials such as trace quantities of fission products and transuranics, the design shall provide for the safe handling of other hazardous materials (e.g., acids, bases, organic solvents, fluorine, hydrogen, hydrogen fluoride, and magnesium) used or generated during recovery operations.

1322-5 CONFINEMENT SYSTEMS

1322-5.1 General

The following provisions are considered typical for a UCRF confinement system. The actual confinement system requirements for a specific UCRF shall be determined on a case-by-case basis. Generally, UCRFs use two confinement systems. The primary confinement system encloses or confines the uranium materials being processed and the materials used to process the uranium. The secondary confinement consists of the structures and associated ventilation systems that surround the operating areas that house the primary confinement system. The operating areas shall include those areas that are not normally expected to become contaminated. The secondary confinement system barriers are those that separate the outside environment and free access areas, such as offices and lunch rooms, from potential contamination.

1322-5.2 Primary Confinement System

The primary confinement system consists of barriers, enclosures, including their associated ventilation or atmosphere control systems, process piping and vessels, and so forth. Its principal function is to prevent the release of hazardous substances into the operating areas.

The integrity of the primary confinement system shall be ensured for all normal operations, anticipated operational occurrences, and for the DBAs it is required to withstand. Breaches of the primary confinement barrier (e.g., due to glove or seal failure) are acceptable if the off-gas treatment system is capable of maintaining an adequate inflow of air for the specified breach size and location. Some portions of the primary confinement may not form a complete physical enclosure. For these, the primary confinement function shall be ensured by adequate air flow and appropriate process equipment design.

If needed, conveyors shall be used to interconnect glove boxes or other primary confinement enclosures to minimize introduction and removal of materials from the system. The primary confinement system criteria shall be applied to these interconnections.

Special design features shall be considered to ensure safe introduction and removal of materials from process confinements.

All process vessels that could contain uranium shall be vented to the process off-gas system, which shall route off-gas through pretreatment, if needed, and HEPA filtration. Typical pretreatment systems include features such as cyclone dust collection systems, different types of filters, cold traps, liquid condensers, solvent adsorption systems, and aqueous solution scrubbers. Nuclear criticality safety shall be considered during the design of the pretreatment and HEPA filtration systems.

1322-5.3 Secondary Confinement System

The secondary confinement system generally consists of the confinement barriers and associated ventilation systems that surround or confine the operating areas that house the process system and its primary confinement.

The secondary confinement system shall be designed to remain functional during normal operations and anticipated operational occurrences. It shall be capable of performing its necessary safety functions during and following the DBAs it is required to withstand.

The operating area compartments shall be equipped with sensors to detect releases of hazardous materials from the primary confinement system and provide appropriate alarms. Commensurate with the potential hazard, consideration shall be given to the use of redundant sensors.

Penetrations of the operating area confinement barriers shall be minimized. When practical, all equipment components not functionally required to operate directly in the presence of radioactive materials shall be located outside the operating area compartments. All penetrations of the secondary confinement shall have positive seals to prevent the migration of contamination out of the operating area.

Each secondary confinement compartment shall be supplied with ventilation air from the building ventilation system. Exhaust ventilation shall be handled by a system with sufficient capacity to ensure an adequately controlled ventilation flow as required in the event of a credible breach in the operating compartment confinement barrier. Pressure in the compartments shall be negative with respect to the building ventilation system. The secondary confinement exhaust ventilation system shall be equipped with HEPA filtration.

1322-6 EFFLUENT CONTROL AND MONITORING

1322-6.1 Radioactive Solid Waste

The solid radioactive wastes typically associated with UCRFs that shall be considered during the design include but are not limited to uranium, uranium-contaminated solid waste, and nonrecoverable scrap (e.g., prefilters, HEPA filters, used gloves). In addition, there will be the general process trash (e.g., waste, paper, plastic bags). Nuclear criticality safety shall be considered in the design of the radioactive solid waste processing facility.

1322-6.2 Radioactive Liquid Waste

The liquid radioactive wastes typically associated with UCRFs that shall be considered during the design include but are not limited to uranium-contaminated liquid waste and nonrecoverable scrap (e.g., liquid filter sludge, effluent contaminated solvents, contaminated oil), and contaminated laundry waste. Nuclear criticality safety shall be considered in the design of the liquid radioactive waste processing facility.

1322-6.3 Effluents

1322 -6.3.1 Airborne Effluents

The airborne radioactive wastes typically associated with UCRFs that shall be considered during the design include but are not limited to airborne particulate material generated during processing (e.g., airborne grinding dust) and vapors and gases used or generated during the processing. Nuclear criticality safety shall reconsidered in the design of the airborne effluent systerm.

All exhaust outlets that may contain uranium shall be provided with two monitoring systems. These monitoring systems shall comply with Section 1589-99.0.1, Radioactive Airborne Effluents.

1322-7 DECONTAMINATION AND DECOMMISSIONING

The facility shall include a special, permanent decontamination process capability in a dedicated area that has the appropriate equipment and utilities for decontamination of equipment.

1322-8 STORAGE FACILITIES

The storage requirements of Section 1306, Unirradiated Enriched Uranium Storage Facilities, shall be considered for the storage of enriched uranium.

1323 RADIOACTIVE LIQUID WASTE FACILITIES

1323-1 COVERAGE

Section 1300, General Requirements, shall apply. These requirements are *in addition to* the requirements of that section and other applicable sections of these criteria, particularly those sections numbered -99.0, Nonreactor Nuclear Facilities–General.

RLWFs are used to store, treat, and dispose of the range of liquid wastes generated by DOE nuclear facilities and reactor facilities. This waste includes low-level, high-level, and transuranic-contaminated (to include enriched uranium and uranium-233) liquid waste. These radioactive liquid waste facilities may be separate facilities or they may be an adjunct to another type of a nuclear facility (e.g., a high-level waste processing line associated with a reprocessing facility). The environmental, and safety, and health concerns to be addressed to fulfill the design requirements for these facilities vary significantly according to the nature of the waste, the waste management techniques that are implemented, and the characteristics of the facility site.

1323-2 OBJECTIVES

The design objective shall be to ensure that conservatively estimated consequences of normal operations and credible accidents are limited in accordance with the guidelines contained in Section 1300-1.4, Guidance on Limiting Exposure of the Public.

1323-3 NUCLEAR CRITICALITY SAFETY

Nuclear criticality safety at radioactive liquid waste facilities is applicable to those facilities that store or process enriched uranium, uranium-233 or transuranic-contaminated liquid waste. For other radioactive liquid waste facilities, nuclear criticality safety is not a design or operational consideration.

Nuclear criticality control provisions for a radioactive liquid waste facility shall include the following:

- Radioactive liquid waste process systems shall minimize the carry-over of sludges, fines, or precipitates of fissile material and other material capable of sustaining a chain reaction from geometrically favorable portions of the facility to other areas of the facility (e.g., from a waste concentrator or evaporator to the low-level storage system).

- A system of positive control and backflow prevention, such as air gaps (e.g., siphon breakers), shall prevent inadvertent transfer of fissile materials and other material capable of sustaining a chain reaction from geometrically favorable or poisoned containers to unsafe containers.

- Heating or cooling jackets in the favorable dimension of geometrically favorable vessels shall preclude a leak in the jacket that causes an unacceptable reduction of the margin of subcriticality.

- Process enclosures and floor drain designs shall preclude the accumulation of fissile material and other material capable of sustaining a chain reaction in the associated traps and piping (e.g., dams and drain plugs).

- Sumps shall be designed for nuclear criticality safety if a credible mechanism exists for accumulating fissile material and other material capable of sustaining a chain reaction (e.g., due to leakage from or failure of the primary confinement boundary).

1323-4 SPECIAL DESIGN FEATURES

1323-4.1 General

The use of multiple barriers shall be emphasized when necessary to restrict the movement of radioactive liquid waste that has the potential for human contact or for reducing groundwater quality below the requirements in DOE 5400.1.

1323-4.2 Collection Systems

Measurement capability shall be provided to determine the volume and radioactivity of wastes fed to collection tank(s).

Individual lines shall be used for each waste stream fed to central collection tanks, where necessary, to prevent chemical reactions or introduction of contaminants such as complexing agents that could interfere with waste decontamination.

The use of traps in radioactive liquid waste lines shall be avoided, and piping shall be designed to minimize entrapment and buildup of solids in the system.

Bypasses that would allow waste streams to be routed around collection tanks shall be avoided.

1323-4.3 Storage and Transfer Systems

Equipment, waste routing, and spare storage volume shall be installed and available to transfer the contents of one tank to another if a tank shows indications of excessive leakage or other conditions that warrant taking the tank out of service. The minimum spare volume shall exceed the maximum liquid content of any one tank.

Provisions shall be made so that liquids can be analyzed prior to transfer.

All transfer lines shall have individual identification.

1323-4.4 Treatment Systems

Basic liquid waste treatment concepts include volume reduction, immobilization of radioactive material, change of composition, and removal of radioactive material from waste. The waste treatment concept(s) for a particular application shall be selected on a case-by-case basis. To the extent practical, however, features shall be included to allow volume reduction and/or waste solidification (immobilization) to forms required for long-term isolation.

Provisions shall be made to adjust liquid waste characteristics prior to treatment to minimize adverse chemical reactions in the treatment system.

There shall be no bypasses or drains in the radioactive liquid waste treatment system by which waste may inadvertently be released directly to the environment.

Provisions shall be made so that effluents from a treatment system can be analyzed.

Recirculating closed-loop cooling systems shall be required for facilities and equipment associated with the storage or treatment of high-heat, high-level radioactive liquid waste. As a minimum, these systems shall comply with Section 1540-99, Special Facilities.

Instrumentation and control systems shall be required at a RLWF to provide monitoring and control capabilities associated with confinement, nuclear criticality safety, and/or radiation projection.

1323-5 CONFINEMENT SYSTEMS

1323-5.1 General

The following provisions arc typical for a RLWF confinement system (see Table 1323-5.1). The actual confinement system requirements for a specific RLWF shall be determined on a

Table 1323-5.1 Typical Confinement Provisions for Radioactive Liquid Waste Facilities

Material Being Confined	Confinement Barriers: Primary	Secondary	Tertiary
High-level liquid waste	Primary storage vessel[1] or Treatment system equipment[3]	Secondary storage vessel[1] or Process cell	Soil barrier[2] or Process building[7]
Low-level liquid	Storage vessel[4] or basin[6]	Dike or berm around vessel	None
	or Treatment system[5]	or Dike or berm	None
Transuranic waste	Storage vessel[4]	Storage building[7]	None
	or Treatment system[5]	or Process building[7]	None

1. Double wall underground storage tanks and transfer piping are typically used to establish primary and secondary confinement barriers. Primary storage tanks have condensers and/ or filters in their vent stream. The space between tanks is also ventilated and the exhaust is filtered.

2. Soil barrier is the engineered backfill material and natural setting surrounding the waste storage tanks. A monitoring capability should be available to detect leakage from the storage tanks into the soil. Credit for soil barriers can not be taken in accident analysis.

3. Typical treatment equipment includes waste calciner, evaporator, or waste fractionization equipment. Treatment also occurs within the storage vessel (e.g., precipitation).

4. Single wall storage tank.

5. Typical treatment concepts include volume reduction, immobilization of radioactive material, change of composition and removal of radioactive material from waste.

6. Interim storage in retention or settling basins.

7. With elevated threshold or other means of confinement.

case-by-case basis.

The degree of confinement required in a radioactive liquid waste facility is both storage-specific and process-specific, but in either case shall suit the most restrictive case anticipated.

Systems, components, and structures that compose the process system and/or primary storage tanks shall be designed to ensure their integrity for all normal operations, anticipated operational occurrences, and DBAs they are required to withstand.

Unless it can be demonstrated that the risk is acceptable, the process system and/or primary storage tanks and associated supports shall be designed to remain fictional following a DBE, and shall facilitate the maintenance of a safe shutdown condition. As a minimum, portions of the process system and/or primary storage tanks whose failure would result in an unacceptable risk and whose functions are necessary to facilitate a safe shutdown condition shall be designed to remain functional following a DBE. Enriched uranium, uranium-233, and transuranic liquid waste processes and/or primary storage tanks shall meet these requirements. The need to meet these requirements for low-level liquid wastes shall be determined on a case-by-case basis and shall be commensurate with the potential hazards associated with the waste.

The primary confinement system consisting of the process equipment and/or primary storage tanks shall be designed to operate under process conditions that prevent or minimize the probability of potential explosive chemical reactions.

Spills, overflow, or leakage from storage vessels or other primary confinement structures shall be collected and retained within a suitable secondary confinement structure (e.g., secondary vessel, dike or berm, elevated threshold within a storage or process building, etc.). The secondary confinement structure shall be capable of retaining the maximum radioactive liquid waste inventory that may be released by a spill, overflow, or leak from the primary confinement structure. For outdoor applications, the capacity must also include maximum predicted precipitation. The structure shall also be designed to preclude overtopping due to wave action from the primary vessel failure and, in outdoor applications, to wind-driven wave action. The capability shall exist to transfer such collected liquid from the secondary confinement structure to a suitable storage location.

Directly buried storage tanks shall be designed in accordance with the applicable requirements specified in DOE 5400.1. The use of directly buried storage tanks should be avoided if at all possible.

1323-5.2 High-Level Liquid Waste Confinement

The following shall apply to the high-level liquid waste confinement system:

- At least one confinement system shall be designed to Withstand the effects of man-made events and DBAs.

- The process cell and/or secondary storage tank confinement and associated ventilation systems shall be designed to remain functional during normal operations, anticipated operational occurrences and for the DBAs they are required to withstand.

- The tertiary confinement system shall be designed to function during normal operations, anticipated operational occurrences and for the DBAs it is required to withstand. It shall be designed to ensure that it can withstand the effects of severe natural phenomena and man-made events, including the DBAs and the DBF initiated by these events, and remain functional to the extent that the guidelines in Section 1300-1.4.2, Accidental Releases, are not violated.

- Tank and piping sytems used for high-level liquid waste collection, treatment, and storage shall be of welded construction to the fullest extent practical. Materials of construction shall be selected to minimize all forms of corrosion. Consideration shall be given to stress relieving, welding parameter controls, etc., depending on the materials used. Fatigue failure should be a design consideration where temperature cycling is required (i.e., evaporator systems, etc.).

- Potential nonuniform distribution of decay heat caused by solids in the waste shall be considered in the design of storage tanks and any associated cooling system. Agitation of tank contents shall be provided, when necessary, to maintain temperature gradients in the waste within acceptable limits.

- Double-walled piping, multi-pipe encasements, and double-walled tanks shall be used to establish the primary and secondary confinement boundaries in underground portions of high-level liquid waste systems. Provisions shall be made to detect leakage from the primary confinement to the interspace.

- Installation of spare pipe lines between transfer points shall be considered.

Process and waste storage vessels shall be vented through appropriate treatment systems that control the release of radioactive material in gaseous effluents to the extent that the guidelines referenced in Section 1300-1.4.3, Routine Releases, are not exceeded and these releases are ALARA. The design shall ensure the following:

- Off-gas will be suitably pretreated upstream of off-gas treatment equipment to remove or reduce the concentration of chemicals that may adversely affect system operation.

- The venting system will prevent overpressure or vacuum conditions from occurring within vessels.

- The venting system will prevent the buildup of hydrogen from radiolysis.

- Tank overflows will be directed to collection systems.

Integrity of the primary confinement boundary shall be determined by some or all of the following measures:

- Vessel inventory monitoring (e.g., liquid level sensors)

- On-line leakage monitoring for the interspace between double-walled vessels (e.g., airborne activity monitors, sump level sensors, conductivity calls)

- Leakage monitoring outside confinement vessels (e.g., surveillance wells to detect leakage into ground water)

- Capability for periodic visual surveillance, including remote visual surveillance with CCTV

- Periodic evaluation of test coupons of primary tank construction materials that were installed before the tank was placed in service

- Other surveillance or testing measures, as appropriate

1323-5.3 Low-Level Liquid Waste Confinement

The following shall be applicable to the low-level liquid waste confinement system:

- A dike or berm around the process system shall provide secondary confinement for low-level liquid wastes.

- A tertiary confinement system is not required for the low-level liquid waste system.

- Process and waste storage vessel vents shall be provided as discussed in Section 1323-5.2, High-Level Liquid Waste Confinement.

- Retention basins shall comply with DOE 5400.1 and shall be lined, fenced, and posted with appropriate radiation warning signs. A system for monitoring radionuclide migration from the basin shall be available.

- An impervious berm or dike shall be capable of retaining the maximum radioactive liquid waste inventory that may be released by a leak or failure of a primary confinement vessel. A capability shall exist to transfer waste that has leaked into the secondary confinement.

1323-5.4 Transuranic-Contaminated Liquid Waste Confinement

The following shall be applicable to the transuranic-contaminated (to include enriched uranium and uranium-233) liquid waste confinement system:

- A storage or process building shall provide ssecondary confinement for transuranic-contaminated liquid wastes.

- Transuranic-contaminated liquid waste systems do not require tertiary confinement.

- Tank and piping systems used for transuranic-contaminated waste collection, treatment, and storage shall be of welded construction to the fullest extent practical. Materials of construction shall be selected to minimize all forms of corrosion. Consideration shall be given to stress relieving, welding parameter controls, etc., depending on the materials used. Fatigue failure should be a design consideration where temperature cycling is required (i.e., evaporator systems, etc.).

- Process and waste storage vessel vents shall be provided as discussed in Section 1323-5.2, High-Level Liquid Waste Confinement.

- Integrity of the primary confinement boundary shall be determined as discussed in Section 1323-5.2, High-Level Liquid Waste Confinement.

- Nuclear criticality safety shall be considered in the design of primary and secondary confinement structures and components.

1323-6 EFFLUENT CONTROL AND MONITORING

1323-6.1 Contaminated Solid Waste

The solid radioactive wastes typically associated with RLWFs that shall be considered during the design include but are not limited to waste calciner products, evaporator bottoms, and general trash (e.g., paper, rags, gloves). Nuclear criticality safety shall be considered in the design of the solid radioactive waste processing facility.

1323-6.2 Contaminated Liquid Waste

1323-6.2.1 Process Wastes

Disposal operations involving discharge of low-level liquid waste directly to the environment or on natural soil columns is prohibited, unless specifically approved by the cognizant DOE authority. Techniques such as solidification prior to disposal or in-plain immobilization shall be used.

The liquid radioactive wastes typically associated with RLWFs that shall be considered during the design include but are not limited to low-level, high-level, and transuranic-contaminated liquid wastes. Nuclear criticality safety shall be considered in the design of the liquid radioactive waste processing facility.

1323-6.3 Effluents

1323-6.3.1 Airborne Effluents

The airborne radioactive waste sources typically associated with RLWFs that shall be considered during the design include but are not limited to radioactive liquid waste process vessel vents, and high-level liquid radioactive waste collection and storage tank vents. Effluent system designs shall preclude the holdup or collection of fissile material or other material capable of sustaining a chain reaction in portions of the system that are not geometrically favorable. Nuclear criticality safety shall be considered in the design of airborne effluent systems.

All exhaust outlets that may contain radioisotopes other than ambient levels of those naturally occurring in the environment shall be provided with two monitoring systems. These monitoring systems shall comply with Section 1589-99.0.1, Radioactive Airborne Effluents.

1324 RADIOACTIVE SOLID WASTE FACILITIES

1324-1 COVERAGE

Section 1300, General Requirements, shall apply. These requirements are *in addition to* the requirements of that section and other applicable sections of these criteria, particularly those sections numbered -99.0, Nonreactor Nuclear Facilities-General.

Radioactive solid waste facilities store, treat, and dispose of the range of solid waste generated by DOE nuclear facilities and reactor facilities. This waste contains high-level, low-level, and transuranic-contaminated solid waste including radioactive mixed waste. These radioactive solid waste facilities may be separate facilities or they may be adjunct to another type of nuclear facility (e.g., a high-level solid waste storage facility associated with a reprocessing facility). The environmental, safety, and health concerns to be addressed to fulfill the design requirements for these facilities vary significantly according to the nature of the waste, the waste management techniques that are implemented, and the characteristics of the facility site.

For those DOE facilities regulated by the NRC (see 10 CFR 60.1 and 10 CFR 61), the requirements specified in 10 CFR 60 and 10 CFR 61 shall take precedence if a conflict arises between those regulations and these criteria.

1324-2 OBJECTIVES

1324-2.1 General

The design objective shall be to ensure that conservatively estimated consequences of normal operations and credible accidents are limited in accordance with the guidelines contained in Section 1300-1.4, Guidance on Limiting Exposure of the Public.

1324-2.2 Siting Design Dose Objectives for Normal Operations and Anticipated Operational Occurrences

1324-2.2.1 Disposal (Permanent Isolation) Facilities

For those DOE facilities not regulated by the NRC, the combined annual dose equivalent to any member of the public in the general environment resulting from discharges of radioactive material and direct radiation shall not exceed 25 mrem (0.25 mSv) to the whole body and 75 mrem (0.75 mSv) to any organ (40 CFR 191.03 (b)). WIPP operations are subject to these dose limits. Section 1300-1.4.3, Routine Releases, provides references for additional limits that are applicable to these facilities.

For those DOE facilities regulated by the NRC, the combined annual dose equivalent to any member of the public in the general environment resulting from discharges of radioactive material and direct radiation shall not exceed 25 mrer (0.25 mSv) to the whole body, 75 mrem (0.75 mSv) to the thyroid, and 25 mrem (0.25 mSv) to any other organ (40 CFR 191.03 (a)). Additional requirements specific to these facilities are provided in 10 CFR 60 and 10 CFR 61.

1324-2.2.2 Waste Management and Storage Facilities (Not to Include Disposal)

The references specified in Section 1300-1.4.3, Routine Releases, provide the appropriate dose limits for members of the public for these facilities.

1324-3 NUCLEAR CRITICALITY SAFETY

Nuclear criticality safety at RSWFs is applicable to those facilities that store or process enriched uranium, uranium-233, or transuranic contaminated solid waste. For other radioactive solid waste facilities, nuclear criticality safety is not a design or operational consideration.

Nuclear criticality control provisions for a RSWF shall consider the following:

- Design of radioactive solid waste storage and/or process systems to prevent the carry-over of fissile material and other material capable of sustaining a chain reaction from geometrically favorable portions of the facility to other areas of the facility (e.g., from a compaction area to a storage area)

- A system of positive control and backflow preventers, such as air gaps (siphon breakers), to prevent inadvertent transfer of fissile materials and other material capable of sustaining a chain reaction from geometrically favorable or poisoned containers to unsafe containers

- Inclusion of heating or cooling jackets in the favorable dimension of geometrically favorable vessels to preclude a leak in the jacket from causing an unacceptable reduction of the margin of subcriticality

- The design of sumps for nuclear criticality safety if a credible mechanism exists for accumulating fissile material and other material capable of sustaining a chain reaction (e.g., due to leakage from or failure of the primary confinement boundary and/or cooling water system)

1324-4 RADIATION PROTECTION

For those DOE facilities regulated by the NRC, the occupational radiation protection requirements specified in 10 CFR 20 and DOE 5480.11, both apply (the most conservative limits taking precedent).

1324-5 SPECIAL DESIGN FEATURES

1324-5.1 General

Process equipment off-gas treatment systems shall be designed to ensure their integrity for normal operations, anticipated operational occurrences, and for the DBAs they are required to withstand.

Cooling water systems or cooling air systems shall be provided, where required, for facilities and equipment associated with the interim storage or treatment of high-level radioactive solid waste, and to ensure the long-term integrity of the primary confinement boundary. As a minimum, cooling water systems shall comply with Section 1540-99, Special Facilities. To the extent practicable, passive cooling means shall be used for air cooling systems. If a cooling air system is provided to ensure an acceptable temperature of the stored material, it shall be designed as a safety class system.

Instrumentation and control systems shall be required at a RSWF to provide monitoring and control capabilities associated with confinement, nuclear criticality safety, and radiation protection.

1324-5.2 High-Level Waste Disposal Facility Confinement

During the short-term period following emplacement when short-lived nuclides dominate the hazard associated with a disposal facility, the engineered system of barriers shall remain effective and shall contain the emplaced wastes. This time period is considered to include at least 300 years but not more than 1,000 years following permanent closure. Technical criteria associated with the engineered system of barriers shall address the following:

- Establishment of a high-integrity confinement system during emplacement (limit the rate of release of radionuclides from the system)
- In-situ stresses affecting the engineered system of barriers
- Corrosion affecting the engineered system of barriers
- Radiological effects on barrier integrity
- Contact with groundwater

During the long-term period, reliance shall not be placed on the engineered system of barriers to contain emplaced waste. Confinement during the long-term period shall be accomplished by the geologic setting. Technical criteria associated with the geologic setting shall address the following:

- Leaching characteristics of waste and waste binders
- Site and soil characteristics, including fractures, porosity, hydraulic conductivity, sorption, hydraulic gradient, and thermal gradient
- Long-term geologic stability

- Groundwater travel time
- Absence of resources that would be an incentive for human intrusion
- Stability of rock mass

The facility shall be designed to allow retrieval of wastes during the 50-year period following emplacement and before permanent closure of the facility.

1324-5.3 Low-Level Waste Disposal Facility Confinement

Low-level solid waste that is disposed to the ground shall be confined by a site-specific system of barriers that may include, but not necessarily be limited to, waste form, waste packaging, and the geologic setting.

When site permeability characteristics do not provide the required confinement capabilities, the confinement system shall be augmented by the following:

- Constructing low permeability walls around the low-level waste
- Lining the walls and bottom of the excavated area with low permeability material
- Other suitable methods for reducing permeability

Means shall be provided to minimize contact of emplaced low-level waste with water. Active water control measures shall not be required following permanent closure. Typical requirements for water control are as follows:

- Placing a layer of highly permeable material (e.g., sand, gravel) beneath the low-level waste to channel any permeating water to a sump
- Mounding the soil surface to facilitate surface water runoff
- Use of a suitable low-permeability cover material (e.g., clay) over the disposal area to prevent contact of the waste by infiltrating rainwater. This cover material shall be protected by a layer of overburden (e.g., sand, gravel, top soil).
- A site diversion system for surface water runoff during operation of the facility. (This system shall not be required following site permanent closure.)
- Temporary protective covers (e.g., tarpaulin) before the completion of the natural in-place soil barrier over the low-level waste
- Revegetation of the overburden layer
- Other suitable and reliable means for minimizing water contact with low-level waste

1324-6 CONFINEMENT SYSTEMS

1324-6.1 General

The following provisions are typical for a RSWF confinement system. The actual confinement system requirements for a specific RSWF shall be determined on a case-by-case basis.

The degree of confinement required in a radioactive solid waste facility is both storage-specific and process-specific, but in either case shall suit the most restrictive case anticipated.

In general, the primary contamination confinement shall be the radioactive solid waste process systems equipment and associated off-gas or vent systems during the treatment stage of processing. In special cases, such as radioactive solid waste facilities where the processes or storage include corrosive or noxious materials, the radioactive solid waste process or storage system shall be totally enclosed and provided with its own ventilation system and off-gas cleanup system. In such cases, the radioactive solid waste process or storage system shall be treated as the primary confinement system. However, depending on the waste being processed and stored, the primary confinement and secondary confinement shall consist of a site-specific engineered system of barriers (e.g., drums, liners, concrete casks) when the primary confinement described above is not required.

Secondary confinement for radioactive solid waste during treatment shall be a process cell or building and its ventilation system, while for such waste during interim storage, a storage building or structure shall be used.

Tertiary confinements are not required in most cases for radioactive solid waste during the treatment or interim storage phase of the radioactive solid waste management process. However, the final repository for all such solid wastes shall be tertiary confinement by the natural geologic setting that has been selected as a site and for the specific solid wastes processed at the facility.

In addition to these principal confinement systems, features such as change rooms and special access ways shall be used to minimize the spread of radioactive contamination within the facility.

1324-6.2 Primary Confinement System

The primary confinement system consists of process systems equipment and its associated ventilation and off-gas system, storage containers, or other waste and site-specific engineered barriers.

Systems, components, and structures that compose the process system and/or storage containers shall be designed to ensure their integrity for normal operations, anticipated operational occurrences, and for the DBAs they are required to withstand.

As a minimum, portions of the process system and/or storage containers whose failure would result in an unacceptable risk and whose functions are necessary to facilitate a safe shutdown condition shall be designed to remain functional following a DBE. High-level enriched uranium, uranium-233, and transuranic solid waste processes and/or storage containers shall meet these requirements. The need to meet these requirements for other solid wastes shall be determined on a case-by-case basis and shall be commensurate with the potential hazards associated with the waste.

1324-6.3 Secondary Confinement System

The secondary confinement system consists of the process cell barriers and the ventilation systems associated with the cells or building, or a storage building or structure. In some cases, a drum, cask, or other waste and site-specific engineered barrier shall provide secondary confinement.

The process cell and/or building confinement barriers and associated ventilation systems shall be capable of performing their necessary functions following a DBE. Other secondary confinements shall be considered to determine the need to meet these requirements commensurate with the hazards associated with the radioactive solid waste to be confined.

The secondary confinement shall be designed to ensure that it can withstand the effects of severe natural phenomena and man-made events, including the DBAs and DBF initiated by these events, and remain functional to the extent that the guidelines in Section 1300-1.4.2, Accidental Releases, are not violated.

All penetrations of the secondary confinement shall have positive seals to prevent the migration of contamination out of the secondary confinement area.

Process cells shall be supplied with ventilation air from the building ventilation system, and shall be provided exhaust ventilation with sufficient capacity to ensure an adequate controlled ventilation flow as required in the event of a credible breach in the secondary confinement barrier. Pressure in the compartments shall be negative with respect to the building ventilation system. Special features (e.g., air locks or enclosed vestibules) shall be considered for access through secondary and tertiary confinement barriers.

1324-6.4 Tertiary Confinement System

The natural geologic setting composes the tertiary confinement system.

The tertiary confinement system shall function during normal operations, anticipated operational occurrences, and the DBAs it is required to withstand. It shall be capable of performing its necessary functions following a DBE.

The tertiary confinement shall remain functional following DBAs and the severe natural phenomena postulated for the facility site. In addition, the tertiary confinement systerm shall meet the following performance objectives:

- Following permanent closure, ongoing site maintenance shall not be needed.

- In the absence of unplanned natural processes or human contact with a low-level waste disposal facility, calculated contaminant levels in groundwater at the site boundary shall not exceed the maximum contaminant levels established in 40 CFR 141.

- In the event of human-induced activities following permanent closure, or reasonably foreseeable but unplanned natural processes, the guidelines of Section 1300-1.4.2, Accidental Releases, shall not be violated. Institutional controls may relied on for a limited time following closure to preclude reclamation activities at a low-level waste disposal site. For the purposes of calculation, these controls shall not be relied on for more than 100 years following permanent closure.

1324-7 EFFLUENT CONTROL AND MONITORING

1324-7.1 Radioactive Solid Waste

The fundamental radioactive solid waste treatment concepts include volume reduction, immobilization of, change of imposition, and removal of radioactive material from the waste. The waste treatment concept(s) for a particular application shall be selected on an individual case basis. To the extent practicable, however, features shall be included to allow volume reduction and/or immobilization.

The solid radioactive wastes typically associated with RSWFs that shall be considered during the design include but are not limited to fuel cladding hulls, spent fuel elements intended for disposal, solidified high-level liquid waste, nontransuranic waste (e.g., waste dryer solids, nonfuel bearing components), and general trash (e.g., paper, rags, gloves). Nuclear criticality safety shall be considered in the design of the solid radioactive waste processing facility.

1324-7.2 Radioactive Liquid Waste

1324-7.2.1 Process Wastes

The liquid radioactive wastes typically associated with RSWTs that shall be considered during the design include but are not limited to decontamination soutions, wash down solutions, water collection systems, and contaminated laundry waste. Nuclear criticality safety shall be considered in the design of the radioactive liquid waste processing facility.

1324-7.3 Effluents

1324-7.3.1 Airborne Effluents

The airborne radioactive wastes typically associated with radioactive solid waste facilities that shall be considered during the design include but are not limited to the airborne effluents from process system vents and fission product gases. Effluent system designs shall preclude the holdup or collection of fissile material and other material capable of sustaining a chain reaction in portions of the system not geometrically favorable. Nuclear criticality safety shall be considered in the design of airborne effluent systems.

Exhaust outlets that may contain transuranics or fission products shall be provided with two monitoring systems. These monitoring systems shall comply with Section 1589-99.0.1, Radioactive Airborne Effluents.

1325 LABORATORY FACILITIES (INCLUDING HOT LABORATORIES)

1325-1 COVERAGE

Section 1300, General Requirements, shall apply. These requirements are *in addition to* the requirements of that section and other applicable sections of these criteria, particularly those sections numbered -99.0, Non reactor Nuclear Facilities-General, and -99.1, Laboratory Facilities (Including Hot Laboratories).

Hot laboratories include those facilities where hot cells, glove boxes, hoods, and other similar enclosures are used for such laboratory work as isotope production, inspection of spent reactor fuel, prototype processes, metallurgical testing, etc., and are included under the general category of "Laboratory Facilities."

1325-2 OBJECTIVES

The design objective shall be to ensure that conservatively estimated consequences of normal operations and credible accidents are limited in accordance with the guidelines contained in Section 1300-1.4, Guidance on Limiting Exposure of the Public.

1325-3 NUCLEAR CRITICALITY SAFETY

Because the spectrum of processes and hazards that may be present at laboratory facilities (including hot laboratories) is usually large, specific guidelines for nuclear criticality safety for these facilities are not possible. The specific requirements for nuclear criticality safety at these facilities shall be considered on a case-by-case basis.

1325-4 CONFINEMENT SYSTEMS

1325-4.1 General

A special feature of a laboratory facility to be considered in the design criteria is confinement of the process or operation. The following provisions are typical for a laboratory facility confinement system. The actual confinement system requirements for a specific laboratory facility shall be determined on a case-by-case basis.

The following are typical characteristics of the three principal confinement systems. The number and arrangement of these confinement systems shall be determined on an individual basis considering the potential hazardous material associated with the facility.

Consideration shall be given to the installation of radioiodine adsorber units in the exhaust ventilation/off-gas system to reduce the radioiodine concentration in the effluent to the extent that the limits in the references specified in Section 1300-1.4.3, Routine Releases, are not exceeded. Additionally, the design shall incorporate ALARA concepts to minimize impact on both the operators, the public, and the environment. Acceptable criteria for the design of these units is found in ERDA 76-21.

1325-4.2 Primary Confinement System

In hot laboratories, the primary confinement usually consists of items such as a hot cell, glove box, process piping, tank, fume hood, etc., and the volume enclosed is normally contaminated.

The integrity of the primary confinement system shall be ensured for normal operations and anticipated operational occurrences. The primary confinement volume and isolation systems, as appropriate, shall be compartmentalized to isolate high-risk areas and to minimize the potential effects of the DBAs they are required to withstand.

The primary confinement system, including the ventilation and off-gas system, shall be shielded, as appropriate, to maintain occupational radiation exposure ALARA and within the limits specified in DOE 5480.11.

The primary confinement system(s) shall be designed to operate under process renditions that prevent or minimize the probability of potential explosive chemical reactions and shall use ALARA design principles to minimize exposures.

Design features for primary confinement for laboratory facilities and processes are facility-specific. The following requirements shall be appropriately applied in the design of a laboratory facility primary confinement system(s):

- Design features for introduction and removal stations to ensure the safe introduction and removal of material and maintenance equipment to and from the primary confinement
- Separate ventilation system or off-gas treatment system with appropriate air-cleaning capability (e.g., HEPA filtration, radioiodine adsorbers, scrubbers). The use of an inert gas atmosphere within the primary confinement shall be considered when handling pyrophoric material or tritium.
- The ventilation and cleanup systems associated with the primary confinement shall generally not be shared with secondary and tertiary confinement systems.
- The operating pressure in the primary confinement shall be negative with respect to the secondary confinement.
- Tanks within the primary confinement shall vent to the off-gas treatment system.
- Glove boxes
- Hot cells

Glove boxes shall meet the following criteria:

- Corrosive gases or particles from vats, scrubbers, and similar equipment shall be neutralized prior to reaching HEPA off-gas filters.

- A single filtered exhaust path shall be acceptable when working with low-toxicity materials that do not require dilution or continuous coding.

- Required exhaust flow rates (for air-ventilated glove boxes) shall have the ability to safely confine in-box contaminants when an access port is opened or a glove ruptures (minimum air velocity of 125 linear ft per minute).

- If the glove box is filled with an inert atmosphere, specific design criteria for emergencies (i.e., ruptured glove) shall be incorporated on a ease-by-case basis to suit a particular situation (e.g., pyrophoric materials).

Hot cells shall meet the following criteria:

- Space and equipment shall be provided as needed to support accountability, process monitoring, and material control requirements and to meet the performance requirements contained in DOE 5633.3.

- Exhaust prefilters and HEPA filters shall be installed in such a manner as to facilitate filter changing and repairs.

- Stand-by filters shall be incorporated for backup protection during filter changes to allow filter changing without shutting down the exhaust fans. Stand-by filters shall be installed outside the cell and sealed in an acceptable enclosure for direct maintenance.

- All exhaust systems shall have monitors that will provide an alarm if the concentration of the hazardous material in the exhaust exeeeds the limits specified in the facility OSR.

- Sufficient holdup capacity shall be provided for the retention of liquid process wastes until they can be analyzed to determine the need for processing or shown to be within acceptable discharge limits.

1325-4.3 Secondary Confinement System

The secondary confinement system usually consists of the facility operating compartments and associated ventilation systems. the secondary confinement houses the hot cells, glove boxes, fume hoods, etc.

The secondary confinement system shall remain functional for all normal operations, anticipated operational occurrences, and for the DBAs it is required to withstand.

The following design requirements shall be incorporated into secondary confinement systems:

- Design features to minimize the probability of the spread of potential contamination from within the laboratory facility operating areas to areas that are not normally contaminated

- The usc of a ventilation system separate from the primary confinement ventilation system with appropriate air-cleaning capability (e.g., HEPA filtration, radioiodine adsorbers, scrubbers)

- Measures to ensure that the operating pressure in the secondary confinement shall be negative with respect to the tertiary confinement

1325-4.4 Tertiary Confinement System

The tertiary confinement system typically is the exterior laboratory building and its associated ventilation system. It is an area that is not contaminated and houses offices and other clean laboratory facilities.

The following design requirements shall be incorporated into tertiary confinement systems:

- Measures to ensure that the confinement building provides protection for the primary and secondary confinement barriers and for enclosed equipment against the effects of severe natural phenomena and missiles

- Measures to ensure that the tertiary confinement can withstand the effects of severe natural phenomena and man-made events, including the DBAs and DBF initiated by these events, and remain functional to the extent that the guidelines in Section 1300-1.4.2, Accidental Releases, are not violated

- The use of a ventilation system separate from the primary confinement ventilation system with appropriate air-cleaning capabilities (e.g., HEPA filtration, radioiodine adsorbers, scrubbers)

- Measures to ensure that the operating pressure in the tertiary confinement is negative with respect to the atmosphere

The secondary and tertiary confinement ventilation systems may be shared if safety analysis indicates that this type of design is acceptable.

1325-5 EFFLUENT CONTROL AND MONITORING

1325-5.1 Radioactive Solid Waste

The solid radioactive wastes typically associated with laboratory facilities including hot laboratories that shall be considered during the design include but are not limited to broken and/or obsolete laboratory equipment from primary confinements, general process trash (e.g., filters, waste paper, gloves, plastic bags). Since hot laboratories often contain a large variety of processes within the facilities, the potential solid radioactive wastes to be processed shall be considered on a facility-specific basis.

1325-5.2 Radioactive Liquid Waste

1325-5.2.1 Process Wastes

The liquid radioactive wastes typically associated with hot laboratories that shall be considered during the design include but arc not limited to uranium, plutonium, and other radioactive contaminated liquid wastes, contaminated solvents, contaminated oils, and decontamination solutions. Since hot laboratories often contain a large variety of processes within the facilities, the potential liquid radioactive wastes to be processed shall be considered on a facility-specific basis.

1325-5.3 Effluents

1325-5.3.1 Airborne Effluents

The airborne radioactive wastes typically associated with hot laboratories that shall be considered during the design include but are not limited to relatively short-lived fission product gases and airborne particulate matter. Since hot laboratories often contain a large variety of processes within the facilities, the potential airborne radioactive wastes to be processed shall be considered on a facility-specific basis.

All exhaust outlets that may contain radiological contamination shall be provided with two monitoring systems. These monitoring systems shall meet with the requirements specified in Section 1589-90.0.1, Radioactive Airborne Effluents.

1325-6 DECONTAMINATION AND DECOMMISSIONING

Due to the nature of some laboratory facilities (including hot laboratories), their life times may be relatively short when compared to production-scale facilities; thus, consideration shall be given during the design of the facility to plans for decommissioning. All designs shall provide for ease of decontamination for this purpose.

1326 TRITIUM FACILITIES

1326-1 COVERAGE

Section 1300, General Requirements, shall apply. These requirements are *in addition to* the requirements of that section and other applicable sections of these criteria, particular) those sections numbered -99.0, Nonreactor Nuclear Facilities–General.

A tritium facility is a facility that processes, handles, or stores large inventories of tritium in either gaseous, oxide, or hydride forms. Examples of these facilities include tritium target processing facilities, tritium storage facilities, tritium loading facilities and fusion gas test loops. A facility shall be classified as a tritium facility rather than a laboratory-scale facility based on the quantity of tritium involved and the scope of tritium handling/processing operations as determined by a safety analysis.

1326-2 OBJECTIVES

The design objective shall be to ensure that conservatively estimated consequences of normal operations and credible accidents arc limited in accordance with the guidelines contained in Section 1300-1.4, Guidance on Limiting Exposure of the Public.

1326-3 NUCLEAR CRITICALITY SAFETY

The general design requirements for nuclear criticality safety in Section 1300-4, Nuclear Criticality Safety, do not pertain to a tritium facility unless the facility can be expected to handle fissile materials. Tritium facilities generally do not contain quantities of fissile materials and material capable of sustaining a chain reaction that warrant a program for nuclear criticality safety.

1326-4 SOURCE AND SPECIAL NUCLEAR MATERIAL

If the safety analysis indicates that either source or special nuclear materials will be handled, then the criteria for the most hazardous material, including that given in ANSI N16.1, shall be applied to the design.

1326-5 RADIATION PROTECTION

1326-5.1 Design Features

Design considerations shall evaluate all maintenance operations offering a potential for significant exposure and where practical they should be designed for remote repair or service. In those instances in which remote or enclosed maintenance cannot be achieved, a compressed-air breathing air system shall be provided to allow the use of supplied-air suits by maintenance personnel. However, every effort shall be made to allow routine maintenance activities to be conducted without the need for supplied breathing air.

Systems shall be designed, to the extent practical, to minimize the conversion of elemental tritium to releasable tritium oxide, which poses a greater radiological risk than elemental tritium.

Although shielding may not be required to maintain occupational radiation exposures ALARA, shielding may be required for other radionuclides that may present a direct radiation hazard, shielding may be required in facilities that handle irradiated tritium production assemblies.

1326-5.2 Radiation Monitoring Systems

Criticality alarm systems and nuclear accident dosimetry are usually not required. However, area radiation monitoring shall be provided as appropriate.

1326-6 SPECIAL DESIGN FEATURES

Special consideration shall be given to the potential explosive mixtures of hydrogen during the handling, processing, and storage of tritium gas.

When tritium is stored in vessels in the solid form (i.e., as uranium tritide), the design shall ensure that the temperatures of the storage vessels do not reach the eutectic temperature for iron and uranium during normal operations, anticipated operational occurrences, and DBA conditions.

Process system components (i.e, piping, valves, and vessels) shall be designed to minimize leakage. The use of packless (metal diaphragm or bellows) valves shall be considered. If valve packing or soft seat inserts are required, the use of nonhalogenated plastics shall be considered. Unless confined within a recirculating glovebox, process system component connections shall be welded to the fullest extent practicable.

In the event process hoods are used, they shall be designed so that the number of personnel entering the hood for equipment removal can be minimized.

When glove boxes are used, the following design features shall be considered:

- Air should not be used for the atmosphere of a recirculating tritium glovebox because of the potential for tritiated water production. Argon or nitrogen is recommended.

- The glovebox atmosphere should be maintained at a pressure lower than that of the surroundings and diffusion-resistant material should be used to the maximum extent possible to limit tritium leakage.

To reduce the amount of tritium released by a single equipment failure, the design shall include the following provisions, as practical:

- The capability of completely isolating areas containing tritium process and handling systems from areas normally occupied by personnel

- The capability of isolating the source of tritium

- The location of tritium monitors to allow the detection of conditions requiring corrective or protective actions

Primary confinement barrier design shall avoid the use of materials that are subject to hydrogen embrittlement.

Tritium process and handling systems shall use, wherever possible, nonflammable hydraulic lubricating, and cooling fluids.

The design of facilities that use large quantities of tritium shall include an emergency tritium gas cleanup system to reduce tritium releases to the environment and mitigate the consequences of an accident involving a failure of a tritium system pressure boundary, unless a safety analysis demonstrates that the system is not required.

A surveillance system shall be provided to monitor the integrity of all process piping, tanks, and other containment equipment, including those used for liquid effluents, and other primary confinement components.

1326-7 CONFINEMENT SYSTEMS

1326-7.1 General

The following provisions are typical for a tritium facility confinement system. The actual confinement system requirements for a specific facility shall be determined on a case-by-case basis.

The degree of confinement required at an individual tritium facility will depend on the form and quantity of tritium that could potentially be released. In general, tritium gas shall be contained in tanks and piping systems that are enclosed in a secondary confinement building or totally within primary confinement enclosures such as glove boxes and fume hoods.

When pressure or missile-producing accidents within a glove box are credible accidents and would result in failure of the glove box or process room, consideration shall be given to using an alternative confinement technique.

1326-7.2 Primary Confinement System

The method of establishing primary confinement shall be compatible with the intended operations. Primary confinement systems shall consist of process piping and vessels, process barriers and enclosures such as fume hoods and glove boxes, and their associated off-gas and ventilation systems. When practical, glove boxes rather than fume hoods shall be used.

The integrity of the primary confinement shall be ensured for all normal operations, anticipated operational occurrences, and for the DBAs it is required to withstand.

The use of stack-vented rupture disks, pressure relief valves, seal pots, or bubbler traps shall be considered to prevent overpressurization and subsequent explosive disruption of the primary confinement system.

Features shall be provided to ensure safe introduction and removal of materials from process confinements.

Suitable traps or other effluent recovery systems shall be provided for process equipment vents to reduce tritium releases.

1326-7.3 Secondary Confinement System

The secondary confinement systems shall include with their associated ventilation systems, a confinement building or appropriate confinement barriers that enclose the primary confinement system.

The secondary confinement system shall be designed to remain functional during normal operations, anticipated operational occurrences, and during and following the DBAs it is required to withstand.

The use of stack-vented rupture disks, pressure relief valves, seal pots, or bubbler traps shall be considered to prevent overpressurization and subsequent explosive disruption of the secondary confinement system.

If the facility building is not part of the secondary confinement system, its failure as a result of severe natural phenomena or other postulated DBAs shall not prevent the secondary confinement system from performing its necessary safety functions.

Facilities that contain large quantities of tritium shall include an emergency tritium gas cleanup system in the secondary confinement areas to reduce the release of tritium resulting from primary confinement failures, unless a safety analysis demonstrates that the system is not required.

Penetrations of the secondary confinement harriers shall be minimized. All penetrations shall prevent the migration of tritium contamination and ensure the proper differential pressure for confinement ventilation flow.

When gloveboxes are used as secondary confinements, a tritium effluent removal system to handle tritium leakage from primary confinement systems shall be required unless safety analysis indicates that it is not required.

Each secondary confinement area or compartment shall be supplied with ventilation air with sufficient capacity to ensure an adequately controlled ventilation flow as required in the event of a credible accident breach in a secondary confinement barrier.

1326-8 EFFLUENT CONTROL AND MONITORING

1326-8.1 General

All exhaust stacks that may contain tritium shall be provided with appropriate monitoring systems.

1326-8.2 Contaminated Solid Waste

The solid radioactive waste typically associated with tritium facilities that shall be considered during the design include materials used to absorb liquid tritium waste, adsorber materials used in molecular sieves, and adsorber beds to remove oxidized tritium gas that cannot be recovered from equipment vents and exhaust systems.

The potential pressure buildup because of radiolysis in sealed containers of tritium-contaminated waste shall be considered in the design of these canisters, waste storage areas, and in the development of waste-handling equipment.

1326-8.3 Contaminated Liquid Waste

The liquid radioactive wastes typically associated with tritium facilities that shall be considered during the design include tritium-contaminated oils, liquid tritium resulting from the oxidation of tritium gas, and contaminated liquids from decontamination operations.

1326-8.4 Effluents

1326 -8.4.1 Airborne Effluents

The airborne radioactive effluents typically associated with tritium facilities that shall be considered during the design include tritium gas and oxides that are not removed by molecular sieves or adsorber beds from process system vents and exhaust systems.

All exhaust outlets that may maintain tritium shall be provided with two monitoring systems. These monitoring systems shall comply with 1589-99.0.1, Radioactive Airborne Effluents.

1326-9 DECONTAMINATION AND DECOMMISSIONING

A dedicated area furnished with appropriate equipment and utilities for decontamination of tools and as much equipment as practical shall be considered for inclusion in the design of the facility. Tritium adsorbed on metal surfaces can be rapidly liberated when the metal is heated whereas water, detergents, and certain solvents are only moderately effective in removing tritium contamination. This property should be considered in the design of decontamination facilities.

1326-10 STORAGE FACILITIES

Although tritium is classified as “Other Nuclear Material,” which generally requires safeguarding at Category IV levels, depending on the quantity and form, tritium requires safeguarding at the Category III level.

The appropriate special design features in Section 1326-6, Special Design Features, shall be considered for the storage of tritium in vessels in the solid form.

1326-11 PHYSICAL PROTECTION AND MATERIAL SAFEGUARDS

Tritium is classified as “Other Nuclear Material.”

1328 FUSION TEST FACILITIES

1328-1 COVERAGE

Section 1300, General Requirements, shall apply. These requirements are *in addition to* the requirements of this section and other applicable sections of these criteria, particularly those sections numbered -99.0, Nonreactor Nuclear Facilities-General.

These requirements are primarily concerned with the potential radiological hazard because of the intense neutron radiation associated with fusion machine operation, activated structural and blanket material, in some cases, activated nuclides in the atmosphere of the test cell, and, in the case of tritium fusion facilities, because of the radioactive material inventory of the facility consisting largely of tritium.

It should be noted that some fusion facilities use deuterium rather than tritium as the fuel. Because these facilities do not produce significant radiation fields or contain significant quantities of radioactive materials, the application of the criteria provided in this section to these types of fusion facilities shall be considered on a case-by-case basis.

Examples of fusion facilities are facilities that include magnetic confinement and inertial confinement fusion devices. Fusion devices of interest range from experimental machines that are intended to operate below the break-even point, to experimental or demonstration facilities intended to operate at or beyond the break-even point. It is recognized that an electric power-producing fusion reactor will not exist for many years, and technical advancements during this period can have a significant impact on safety considerations related to such facilities.

Potential hazards that shall be considered in the design of a fusion facility include intense magnetic fields, an intense radiation source, activation products, cryogenic fluids, high-voltage electric power systems, tritium, and in some facilities, laser light. The tritium inventory in a fusion machine and associated primary systems may contain as much as 10 to 100 grams of tritium for small experimental to large demonstration facilities. Tritium processing systems may contain up to 100 grams of tritium, and storage facilities several thousand grams of tritium. Therefore, the total tritium inventory of a fusion facility may range up to 109 curies.

1328-2 OBJECTIVES

The design objective shall be to ensure that conservatively estimated consequences of normal operations and credible accidents are limited in accordance with the guidelines contained in Section 1300-1.4, Guidance on Limiting Exposure of the Public.

1328-3 NUCLEAR CRITICALITY SAFETY

The general design requirement for nuclear criticality safety in Section 1300-4, Nuclear Criticality Safety, are not applicable. A fusion facility does not require a program for nuclear criticality safety.

1328-4 SOURCE AND SPECIAL NUCLEAR MATERIAL

The general design requirements for source and special nuclear material in Section 1300-5, Source and Special Nuclear Material, are not applicable.

1328-5 RADIATION PROTECTION

1328-5.1 Design Features

Systems should be designed, to the extent practical, to minimize the conversion of elemental tritium to releasable tritium oxide, which poses a greater radiological risk than elemental tritium. Furthermore, to reduce radiation exposure due to inhalation and adsorption of tritium through the skin, the provision of an independent compressed-air breathing air system shall be considered to allow the use of air-supplied suits by personnel involved with the maintenance of tritium systems and equipment.

The design shall incorporate shielding where the potential for substantial neutron or gamma radiation is postulated to exist.

1328-5.2 Radiation Monitoring Systems

A criticality alarm system and nuclear accident dosimetry are not required. However, area tritium monitors shall be required.

1328-6 SPECIAL DESIGN FEATURES

Section 1326-6, Special Design Features, shall be considered in the design of tritium process and storage facilities.

Cooling systems shall be provided, as required, for removal of heat from the fusion machine first wall (vacuum vessel), blanket, or other ancillary equipment.

To reduce the amount of tritium released by a single equipment failure, the design shall include the following provisions, as practical:

- The capability of completely isolating areas that house equipment containing tritium from areas normally occupied by personnel

- The capability of isolating sources of tritium

- The location of tritium monitors to allow the prompt detection of conditions requiring corrective or protective actions

When the severity of DBAs require that a containment structure be used, the design pressure and temperature for fusion machine secondary confinement or containment shall be determined considering the effects of energy transport and chemical reactions that may occur following the failure of a fluid system inside the containment. The containment shall be designed to allow periodic leak rate testing. To minimize the release of hazardous materials to the atmosphere, means shall be provided to isolate the primary containment following DBAs that release hazardous material to the containment atmosphere.

The design of fusion facilities' secondary confinement or containment where large quantities of tritium are used shall include an emergency tritium cleanup system to mitigate the consequences of an accident involving a failure of a tritium system pressure boundary, unless a safety analysis demonstrates that the system is not required.

Tritium auxiliary and other systems containing hazardous materials that are located outside of the fusion machine secondary confinement building or containment structure shall be confined by a secondary confinement system.

The secondary confinement system shall be capable of collecting and processing tritium leakage that may occur from tritium auxiliary systems.

The possibly harmful effects of large magnetic fields on operating personnel and equipment shall be considered in the design of the facility. Individuals knowledgeable in the effects of these fields should be consulted for appropriate guidance.

1328-7 CONFINEMENT SYSTEMS

1328-7.1 General

The following provisions are typical for a fusion facility confinement system. The actual confinement system requirements for a specific fusion facility shall be determined on a case-by-case basis.

Confinement of tritium at a fusion facility is the essential element in minimizing potential environmental, safety, and health risks. The degree of confinement required at various locations in a fusion facility will depend on the quantity of tritium that may potentially be released. When significant inventories of tritium (approaching tritium inventories at large demonstration facilities) are involved, the use of a low-leakage containment building rather than a confinement building shall be used for housing the fusion machine, unless a safety analysis demonstrates that containment is not required. In general, the primary confinement shall be provided by the pressure boundary of the fusion machine, its associated vacuum system, and the various tritium systems.

The fusion machine shall be housed in either a secondary confinement or low-leakage containment structure. The auxiliary tritium systems located outside the fusion machine building shall be housed in a secondary confinement structure.

1328-7.2 Primary Confinement System

The primary confinement system shall consist of the primary vacuum vessel and associated vacuum system, tritium (fuel) injection system, and tritium transfer, cleanup, and storage systems.

The confinement shall be designed to withstand a potential hydrogen explosion without loss of confinement function.

The integrity of primary confinement systems, components, and structures shall be ensured for normal operations, anticipated operational occurrences, and for the DBAs they are required to withstand.

1328-7.3 Secondary Confinement System

1328-7.3.1 General

The secondary confinement systems shall consist of a confinement building or low-leakage containment structure that houses the fusion machine. The severity of DBAs and their potential consequences as demonstrated by safety analysis will determine if a low-leakage containment structure is needed. Auxiliary tritium systems located outside the fusion machine building shall be housed in a confinement system.

1328-7.3.2 Fusion Machine Building

The secondary confinement or containment building shall be designed to remain functional during normal operations and anticipated operational occurrences. It shall be designed to ensure that it can withstand the effects of severe natural phenomena and man-made events, including the DBAs it is required to withstand, and remain fictional to the extent that the guidelines in Section 1300-1.4.2, Accidental Releases, are not violated.

The confinement or containment shall operate at a negative pressure with respect to atmospheric pressure.

Penetrations through secondary confinement barriers and containment structures shall be minimized and sealed.

Provisions for isolating the fluid system penetrations through the fusion machine building, secondary confinement building or containment structure to minimize the release of hazardous materials to the environment through fluid system lines shall be considered.

Each secondary confinement area shall be provided with an exhaust ventilation system with sufficient capacity to ensure an adequately controlled ventilation flow as required in the event of a credible breach in a secondary confinement barrier. Exhaust systems shall contain appropriate cleanup systems to minimize the release of hazardous materials. Ventilation systems of containment structures shall include provisions for isolating the supply and exhaust connections.

1328-7.3.3 Auxiliary Systems Located Outside the Fusion Machine Building

The secondary confinement system shall be designed to remain functional during normal operations and anticipated operational occurrences. It shall be designed to ensure that it can withstand the effects of severe natural phenomena and man-made events, including the DBAs it is required to withstand, and remain functional to the extent that the guidelines in Section 1300-1.4.2, Accidental Releases, are not violated.

If the facility building is not part of the secondary confinement system, its failure as a result of severe natural phenomena or other postulated accidents shall not prevent the secondary confinement system from performing its necessary safety functions.

Each secondary confinement area or compartment shall be supplied with ventilation air from the building ventilation system and shall provide exhaust ventilation by a system with sufficient capacity to ensure an adequately controlled ventilation flow as required in the event of a credible breach in a secondary confinement barrier. Pressure in the secondary confinement areas or compartments shall be negative with respect to the building ventilation system and/or atmosphere.

1328-8 EFFLUENT CONTROL AND MONITORING

1328-8.1 Radioactive Solid Waste

The solid wastes typically associated with fusion facilities that shall be considered during the design include components and materials used in the first wall, blanket, or magnets activated by the fusion neutrons, materials used to absorb liquid tritium waste, and adsorber materials used in molecular sieves and adsorber beds to remove oxidized tritium gas that could not be recovered from equipment vents and exhaust systems.

The potential pressure buildup because of radiolysis in sealed containers of tritium-contaminated waste shall be considered in the design of these containers and waste storage areas and in the development of waste-handling equipment.

1328-8.2 Radioactive Liquid Waste

The liquid wastes typically associated with fusion facilities that shall be considered during the design include tritium-contaminated oils, liquid tritium resulting from the oxidation of tritium gas, and contaminated fluids from decontamination operations.

1328-8.3 Effluents

1328-8.3.1 Airborne Effluents

The airborne radioactive effluents typically associated with fusion facilities that shall be considered during the design include tritium gas and oxides that are not removed by molecular sleves or adsorber beds from process system vents and exhaust systems, and activated nuclides in the atmosphere in the fusion machine building.

1328-9 DECONTAMINATION AND DECOMMISSIONING

The facility design shall include a dedicated area furnished with appropriate equipment and utilities for decontamination of tools and as much equipment as practical. Tritium adsorbed on metal surfaces can be very rapidly liberated when the metal is heated, whereas water, detergents, and certain solvents are only moderately effective in removing tritium contamination. This property shall be considered in the design of decontamination facilities.

1328-10 STORAGE FACILITIES

Tritium is classified as "Other Nuclear Material."

When tritium is stored in vessels in the solid form (i.e., as uranium tritide), the design shall ensure that the temperature of the storage vessels does not reach the eutectic temperature for iron and uranium during normal operations, anticipated operational occurrences, and DBA conditions.

1328-11 PHYSICAL PROTECTION AND MATERIAL SAFEGUARDS

Tritium is classified as "Other Nuclear Material."

Division 14
Conveying Systems

1401 General

Elevators, dumb waiters, wheelchair lifts, escalators, and moving walks shall comply with:

- ASME A17.1
- NFPA 70
- ANSI C2
- UBC, Chapter 51, except enclosures
- 29 CFR 1926
- 29 CFR 1910
- UFAS
- NEMA standards
- NFPA 101, Chapter 6

Hoisting, conveying, and material handling systems and equipment for hazardous materials shall meet the requirements established by the cognizant DOE authority.

Hoisting, conveying, and material handling systems that penetrate one or more security barriers shall provide at each such barrier the same degree of penetration resistance and intrusion detection as is required for that barrier by the site-specific security plan. The power distribution and control circuits for such elevators shall meet the design requirements for secure circuits as specified in Section 1640-3, Power Service for Security, Communications, and Alarm Systems.

1420 ELEVATORS

Passenger elevators including those designed to carry freight shall be automatic with push-button controls for each call station.

At least one elevator in each bank of elevators shall be equipped and arranged for fire service operation so that firefighters and other emergency forces can have manual control. The power distribution and control circuits for that elevator or those elevators shall meet the design requirements for secure circuits as specified in Section 1640-3, Power Service for Security, Communications, and Alarm Systems.

The number, size, capacity, type of machinery, types of controls, and other operating characteristics of the elevators to be installed shall be based on an elevator analysis that considers such factors as the following:

- Building size
- Configuration
- Circulation
- Traffic patterns
- Population
- Spacing conditions
- Elevator service functions

Where passenger elevator service is provided and no separate freight elevator service is provided, at least one passenger elevator in each bank shall be designed to carry freight in accordance with Rule 207.1B of ASME A17.1.

All passenger elevators designed to carry freight shall be equipped with hooks to hang protective mats.

All passenger elevators and those designed to carry freight in facilities that are required to be accessible to physically handicapped persons shall comply with UFAS.

Where elevators are designed to be used to transport rescue personnel to and from hazardous areas, they shall be designed and constructed for ease of decontamination.

Where passenger elevator service is provided, an access control system shall be established that meets the requirements specified in the site-specific security plan for the most restrictive security barrier penetrated by that elevator system.

For elevator ventilation, see Section 1550-1.5, Ventilation-Exhaust Systems Design Requirements.

1440 LIFTS

1440-1 WHEELCHAIR LIFTS

In facilities without passenger elevator service where access by physically handicapped persons is required, platform lifts shall be considered for use.

All wheelchair lifts used in facilities that are required to be accessible to physically handicapped persons shall comply with UFAS.

1460 CRANES

All cranes shall be designed consistent with CMAA-70 requirements. Overhead cranes and related equipment for special facilities shall be designed and installed to the same requirements in effect in the building location in which they are installed. Cranes shall have wheel restrainers.

Division 15
Mechanical

1525 MECHANICAL INSULATION

1525-1 APPLICABILITY

Insulation shall be considered for equipment, ductwork, piping, flue pipe, and breeching to minimize energy loss, to prevent condensation, and to provide safe surface temperatures.

All insulation material, media used to apply insulation, and jacketing material shall have a maximum flame spread of not more than 25 fuel-contributed and smoke-developed ratings of not over 50 when tested using UL 723 Test Methods. Exception to the smoke-developed rating of 50 shall be made for exterior underground piping and exterior above-ground piping beyond 15 feet from buildings or individual supports (stanchions).

Asbestos or asbestos-containing materials shall not be used.

1525-2 MINIMIZATION OF ENERGY LOSS

ASHRAE Standard 90 shall be the basis for determining insulation thickness in HVAC systems, service water heaters, and recirculation piping in buildings.

Insulation thicknesses for exterior and underground distribution systems and equipment shall be based on the TIMA Economic Thickness Manual.

1525-3 CONDENSATION PREVENTION

Insulation material, thickness, and jacketing shall be designed to provide an exterior skin surface temperature greater than the minimum anticipated ambient dew point.

1525-4 SAFE SURFACE TEMPERATURES

Insulation shall be provided on hot and cold generation equipment, ductwork, piping, flues or breeching, using a material, thickness, and surface treatment that will maintain the surface temperature between 35ºF and 125ºF for highly conductive (metal) surfaces or between 32ºF and 1500ºF for nonconductive surfaces. See also Section 1555-2.6.8, Plant Insulation.

1530 FIRE PROTECTION

1530-1 GENERAL

Fire protection systems shall comply with DOE 5480.7.

1530-2 IMPROVED RISK CONCEPT FOR FIRE PROTECTION SYSTEMS

1530-2.1 General

Fire protection design shall incorporate an "improved risk" level of fire protection as directed in DOE 5480.7 as well as Section 0110-5, Health and Safety.

1530-2.2 Vital Programs

Fire protection systems for vital programs shall incorporate a "higher standard of protection" than the "improved risk" level as directed by DOE 5480.7.

1530-2.3 Maximum Possible Fire Loss

1530-2.3.1 General

The "improved risk" level of protection requires that the "maximum possible fire loss" shall be the basis for determining the need to provide automatic fire suppression systems and for additional fire protection systems and features. "Maximum possible fire loss" is defined in DOE 5480.7. Criteria I through V as discussed in DOE 5480.7 correspond with Section 1530-2.3.2, Criterion I, through Section 1530-2.3.6, Criterion V. The application of these criteria shall be considered by an experienced fire protection engineer.

1530-2.3.2 Criterion I

Whenever the maximum possible fire loss exceeds $1 million, automatic fire suppression systems shall be provided.

1530-2.3.3 Criterion II

The need for automatic fire suppression systems shall be considered when the maximum possible fire loss is below $1 million.

Some examples of situations where automatic fire suppression systems may be warranted for potential fire losses below $1 million are:

- Facilities that contain critical or long-procurement-time construction items

- A temporary-use trailer used as a control center for a vital one-time activity
- A facility with high public visibility or sensitivity
- Electric power transformers with combustible contents that, if damaged, could result in an extended shut-down of the facilities they serve
- Facilities in which a fire could result in the accidental release of toxic or hazardous materials or emissions
- Cooling towers of combustible construction
- Facilities that can be easily protected by extending automatic sprinkler systems from an adjacent protected facility at a low incremental cost
- Facilities in which a fire could damage more important adjacent facilities
- Facilities that may warrant automatic fire suppression systems in the future
- Facilities where required for protection of human life

1530-2.3.4 Criterion III

Automatic fire suppression systems are not required if all of the following conditions are satisfied:

- The maximum possible fire loss is less than $250,000.
- There is no hazard to human life.
- There is no danger of a fire resulting in release of toxic or hazardous materials or emissions.
- Adequate separation from other facilities is provided
- Important operations or program missions will not suffer unacceptable delays as a result of fire (see DOE 5480.7 for qualification criteria).

1530-2.3.5 Criterion IV

Whenever the maximum possible fire loss exceeds $25 million, the area shall be subdivided with free-standing fire rated walls or suitable redundant fire protection systems to limit the credible loss to less than $25 million even in the event the primary system fails. In no case shall the maximum loss potential exceed the $75 million loss limit established in DOE 5480.7; failure-proof systems such as physical separations shall be provided to prevent this possibility.

Response capability of on-site fire departments and availability of adequate water quantity and pressure at well-locatcd hydrants may he the principal basic method of redundant fire protection for most DOE facilities, but automatic redundant protection systems may be needed to meet or exceed "improved risk" levels of protection for some facilities.

Redundant fire protection systems may include dual water supplies to sprinkler systems, dual piping risers, or valving systems such that adequate redundancy in water supply to the sprinkler heads is provided to cover maintenance or emergency outages of either of the water supply systems; or, may include multiple types of automatic fire suppression systems (e.g., water sprinklers and Halon).

Some DOE sites or facilities must rely on local (e.g., city or county) fire department response capability for redundant protection. The fire department capability to reduce loss due to a well-developed fire shall be considered in terms of the following factors:

- Location of fire station(s) with respect to the facility to be protected
- Staffing of stations (e.g., continuously or "on-call" volunteer)
- Ability to perform initial fire attack as outlined in NFPA 1410
- Method(s) of fire department notification or alarm reception
- Familiarity of station staff with the DOE facility, and training in preparation for effective response to an alarm at the DOE facility
- Degree of commitment that fire department(s) make to respond to fire emergencies in DOE facilities. This factor shall be emphasized.

Portable fire extinguishers, interior fire hose systems, or interior fire detection and alarm systems do not meet the definition of a redundant fire protection system.

1530-2.3.6 Criterion V

The need for redundant fire protection systems or methods, or for supplementing existing redundant fire protection capability, shall be considered on a case-by-case basis when the maximum fire loss potential is below $25 million. Factors to be considered include:

- Fire department response capability
- Hazards involved in the operation
- Operating and program-mission effect of interruption and delays due to fire

1530-3 WATER FLOW AND PRESSURE REQUIREMENTS FOR FIRE PROTECTION

1530-3.1 General

Total volume, pressure, and design flow rate of water necessary to provide fire protection for facilities shall be determined by the methods described in the following paragraphs. All sprinkler or other automatic fire suppression system components shall be UL- or FM-approved for the particular application chosen.

1530-3.2 Occupancy Hazard Classification

NFPA 13 shall be used to determine the Occupancy Hazard Classification for any facility. Light hazard occupancy rules are prohibited.

1530-3.3 Writer Demands for Sprinklered Facilities

1530-3.3.1 Schedule-Designed Sprinkler Systems

For systems designed using pipe schedule methods, NFPA 13 shall be used for calculating water demand in the absence of specific requirements provided by the cognizant DOE fire protection authorities based on unusual occupancies or special hazards.

Precautions shall be taken to ensure that adequate residual pressure exists at full demand flow rate to fulfill the density and coverage requirements for schedule-designed systems. If water supply or pressure is marginal the pressure loss from the base of the riser to the most remote head should be calculated to confirm that the schedule designed-system will meet requirements, or the system shall be hydraulically designed.

1530-3.3.2 Hydraulically Designed Sprinkler Systems

NFPA 13 shall be used to determine water supply requirements for hose streams (gpm) and duration (min). Density curves presented in NFPA 13 shall be used for calculating sprinkler demand for hydraulically designed systems. For hazard classifications not covered in NFPA 13 and certain other special occupancies or hazards, design density and area of coverage shall be as specified by other more appropriate standards referenced in NFPA 13 or project-specific requirements as determined by the cognizant DOE fire protection engineer. For ordinary hazard occupancies and above, hose stream requirements shall be a minimum of 500 gpm regardless of the hose stream demands listed in the above references unless otherwise specified by the DOE project criteria.

Determination of adequacy of water supply shall be made on the basis of actual flow test data gathered using the methods in NFPA 13, Appendix B.

1530-3.3.3 Fire Hydrant Demand

Where reliance is placed on fire department response, either for protection of unsprinklered buildings or where the fire department will serve as redundant (backup) protection, as a general rule the water supply should be adequate to supply at least 0.03 gpm per cubic foot of fuel (building and contents) in the largest fire area (for high-BTU-content fuels, convert to equivalent ordinary BTU loads). This water supply should be available at 20 psig residual pressure at the hydrants.

1530-4 AUTOMATIC SPRINKLER PROTECTION

1530-4.1 General

All sprinkler systems shall comply with NFPA 13.

1530-4.2 Types of Sprinkler Systems

1530-4.2.1 Wet Pipe

Sprinkler systems shall normally be wet pipe using pipe schedule sizes listed in NFPA 13 for ordinary installations. Hydraulic designs shall be considered for all systems. The system shall be hydraulically designed where residual pressure is marginal, water application rate is high, response time is critical, or special risks are involved.

1530-4.2.2 Dry Pipe

In unheated areas or other areas subject to freezing temperatures, dry pipe systems shall be provided. Because of the time delays associated with release of the air in the system, water demands for dry pipe systems shall be computed over areas 30 percent greater than for comparable wet pipe systems. Where the unheated area is small it may be cost effective to install an antifreeze system or small dry pipe system supplied from the wet pipe system in the main heated area.

1530-4.2.3 Preaction

A preaction system shall be used where it is particularly important to prevent the accidental discharge of water. Need for a preaction system shall be based on review by and recommendation of a professional fire protection engineer. The detection system chosen to activate the preaction valve shall have high reliability and a separate alarm/supervisory signal to indicate status. The detection system must be designed to be more sensitive than the closed sprinklers in the preaction system, but should not be so sensitive as to cause false alarms and unnecessary actuation of the preaction valve.

1530-4.2.4 Deluge

For extra hazard areas and specific hard-to-extinguish fuels such as explosives and pyrophoric metals, a deluge system with open sprinkler heads may be used to wet down the entire protected area simultaneously. Deluge systems shall comply with NFPA 13. If quick response is required deluge system piping may be primed with water. The nozzles must be provided with blow-off caps for water-filled deluge systems.

1530-4.2.5 Self-Restoring

Self-restoring sprinkler systems, such as the on-off multicycle system or systems using individual on-off sprinkler heads, shall be considered where the water from sprinklers will become contaminated by contact with room contents, where there is a concern for water damage, or where water supply or storage volume is marginal.

1530-4.2.6 Quick-Response

Where there are high-value concentrations (values per square foot), quick-response sprinklers shall be considered in lieu of conventional sprinklers.

1530-5 SPECIAL PROTECTION SYSTEMS

1530-5.1 General

Special protection systems may be used to extinguish or control fire in easily ignited, fast-burning substances such as flammable liquids, some gases, and chemicals. They shall also be used to protect ordinary combustibles in certain high-value occupancies especially susceptible to damage. Special protection systems supplement automatic sprinklers as described by NFPA and shall not be used to substitute for them except where water is not available for sprinkler protection. The added expense of the supplementary system shall be supported by documented justification.

The selection of a particular special suppression system shall be based on:

- The effectiveness of that system or agent for the type of hazard
- The damage likely to be caused by the extinguishing agent, including cleanup and downtime

1530-5.2 Types of Special Suppression Systems

1530-5.2.1 Water Spray

Installation of water spray systems shall comply with NFPA 15.

1530-5.2.2 Carbon Dioxide

Agent quantity requirements and installation procedures shall comply with NFPA 12.

1530-5.2.3 Dry Chemical

Systems shall comply with NFPA 17.

1530-5.2.4 Foam

Foam systems shall comply with NFPA 11, NFPA 11A, NFPA 16, NFPA 16A, and NFPA 409.

1530-5.2.5 Halon

The installation of Halon 1301 systems and Halon 1211 systems shall comply with NFPA 12A and NFPA 12B, respectively.

1530-6 STANDPIPES AND HOSE SYSTEMS

Installation of standpipe systems shall comply with NFPA 14.

1530-7 PORTABLE FIRE EXTINGUISHERS

Portable fire extinguishers shall comply with NFPA 10.

1530-8 FIRE DETECTION AND ALARM SYSTEMS

1530-8.1 General

All fire detection and alarm devices shall have UL-listed components or be FM-approved. Devices and systems shall comply with NFPA 71, NFPA 72A, NFPA 72B, NFPA 72C, NFPA 72D, NFPA 72E, NFPA 72F, NFPA 72G and NFPA 72H as applicable.

1530-8.2 Alarm Systems

1530-8.2.1 General

Fire alarm systems shall have the following basic features:

- Transmission of signals to the DOE facility fire department alarm center and other constantly attended locations in accordance with the appropriate NFPA Signaling Systems Standard
- Local alarms for the building or zone in alarm
- Trouble signals as required by the appropriate NFPA Signaling Systems Standard
- Emergency battery backup for system operation
- Electric supervision of all circuits as required by the appropriate NFPA standard
- Supervisory devices for all critical functions (valve position switches, water level, temperature).
- Capability of annunciating at least three separate conditions: 1) a fire alarm, 2) a supervisory alarm, and 3) a trouble signal indicating a fault in either of the first two. Annunciation of each condition shall be separate and distinct from the other two.

Fire alarm systems for new DOE buildings shall be compatible with those for the DOE complex where the new building is to be located.

1530-8.2.2 Alarm Actuating Devices

- Alarms that respond to flow of water shall be provided wherever a sprinkler system is installed and shall comply with requirements of the NFPA standard for the type of signaling system used.

- A manual fire notification method such as manual fire alarm boxes shall be provided and located in accordance with the appropriate NFPA standard

- Combined watch reporting and fire alarm systems, if used, shall be in accordance with the appropriate NFPA standard

1530-8.3 Automatic Fire Detection Systems

1530-8.3.1 General

Automatic detection systems may be used to supplement or to actuate extinguishing systems. Automatic fire detectors shall comply with NFPA 72E. Detector spacing shall be in accordance with NFPA 72E, Appendices A, B, and C.

1530-8.3.2 Heat-Actuated Detectors

Heat-actuated detectors are appropriate when any of the following conditions exists:

- Speed of detection is not the prime consideration

- The space is small or confined and rapid heat build-up is expected

- Ambient conditions do not allow the use of other detection devices

1530-8.3.3 Flame-Actuated Detectors

Flame-actuated detectors are appropriate when rapid detection is of prime importance in high hazard areas, such as:

- Fuel-loading platforms

- Industrial process areas

- Hyperbaric chambers

- High ceiling areas

- Atmospheres where explosions or very rapid fires may occur

Since this type of device must "see" the flame to operate, the number of devices and their aiming must be carefully engineered. False trips from extraneous radiation sources are also possible. For the above reasons use of this type of device shall require coordination among the fire protection engineer, DOE project manager, and the equipment manufacturer.

1530-8.3.4 Smoke Detectors

Smoke detectors shall be installed in all areas where required by the appropriate NFPA standard or by the cognizant DOE fire protection authority. Smoke detectors shall be of a type operating on one of the principles described in NFPA 72E. A mixture of detector types may be appropriate. Location and required spacing of smoke detectors shall be determined by the methods of NFPA 72E and its Appendix C. Spacing shall be based on threshold fire size, fire growth rate, and ceiling height as described in these standards.

1530-9 WATER STORAGE AND DISTRIBUTION

Wherever practical, dedicated fire water storage and distribution systems shall be used. If a dedicated fire water supply system cannot be provided, the fire protection water supply shall assure availability regardless of simultaneous process and domestic water usage.

Where automatic sprinkler systems or standpipes are fed from a potable water system, approved check valves shall be installed in sprinkler lead-ins to preclude the introduction of pollutants from systems or recirculation of stagnant water that would contaminate the domestic water system.

Underground fire water mains or combined fire and domestic water mains, including valves, hydrants, and fittings, shall be installed, flushed, sterilized, and tested in accordance with NFPA 24 and Section 0260, Piped Utility Materials. Water storage tanks shall comply with NFPA 22. Fire pumps shall comply with NFPA 20. Water storage shall be sufficient to meet the density, pressure, and duration requirements of NFPA 13.

Whenever feasible, all water distribution systems shall be of the looped grid type providing two-way flow with sectional valving arranged to provide alternate water flow paths to any point in the system.

Fire mains (except those supplying a single hydrant or extensions of existing smaller mains) shall be at least 8 inches. Mains shall be sized to supply the largest fire demand plus the largest domestic and process demand with consideration for residual sprinkler system pressure requirements.

Sprinkler supply lead-ins should be at least 6 inches, except lead-ins of 4 inches may be used for very small sprinkler systems when substantiated by hydraulic calculations. In no case shall the lead-in be smaller than the sprinkler riser.

Where combined fire and domestic-process water systems are used, the supplies to each building shall be arranged and valved so that the domestic and process systems can be shut down without shutting off the fire system supply.

Sprinkler risers should be located at an exterior wall. Sprinkler supply lead-ins should run under buildings the minimum distance possible. Where a riser must be located in a potentially contaminated area, consideration should be given to locating the riser exterior to the building in a heated enclosure.

Outside control valves that can be locked open shall be provided on each supply lead-in,
located if possible a minimum distance of 40 feet from the building. PIVs should be used where possible. If site conditions preclude the use of PIVs, such as where they would be subject to mechanical damage and cannot be properly guarded, OS&Y valves in pits may be used.

Key-operated buried valves shall not be used for sprinkler control valves. In no case shall there be more than one valve controlling a sprinkler supply lead-in.

All lead-ins shall be connected with the sprinkler system at the base of the riser. Alarm valves shall be located as close as practical to the building entry point. Hydrants shall be provided so that hose lays from hydrants to all exterior portions of a protected building are no more than 300 feet. Hydrants shall not be closer to buildings than 50 feet.

1530-99 SPECIAL FACILITIES

1530-99.0 Nonreactor Nuclear Facilities-General

An assessment shall be made early in the design or modification to determine the facility structures, systems, and components that shall be protected against the effects of a DBF and explosion. A fire protection engineer or person knowledgeable in applying the principles of fire protection shall develop the fire protection system. To maximize the protection against fire, the system shall contain art appropriate integration of fire prevention, detection, and suppression features.

Fire protection systems shall not: (1) prevent a facility from achieving and maintaining a safe shutdown condition, (2) prevent the mitigation of DBA consequences, or (3) cause an inadvertent nuclear criticality.

Total reliance shall not be placed on a single fire suppression system. Appropriate backup capability shall be provided.

To ensure that redundant safety class components shall be capable of performing the necessary safety functions, the facility design shall provide appropriate separation against fire, explosion, and failure of fire suppression systems.

Fire protection systems, or portions of them, that must function to control effects of a DBA event (as determined by safety analysis accident scenarios) shall be designed to be functional for all conditions included in the accident scenario. This shall include both the event initial cause and its consequences.

Mechanical- and fluid-system portions of the fire protection system shall meet the appropriate NFPA requirements.

The operation or failure of a fire protection system that interfaces with a safety class system, such as a safety class water system, shall not prevent the safety class system from completing its safety functions when required. Wherever practical, special facilities shall be designed and constructed using building components of fire-resistant and noncombustible material, particularly in locations vital to the functioning of confinement systems. To the extent practicable, combustible materials shall not be used in the construction of process system confinement barriers.

Confinement systems, particularly the building structural shell and its associated ventilation system, shall be designed with the capability of retaining the confinement function during the DBF.

When the use of water sprinkler coverage is precluded because of nuclear criticality or other hazards, nonaqueous extinguishing systems (i.e., inert gas, carbon dioxide, high-expansion foam, or halogenated organics) shall be used.

Fire protection systems shall be designed so that the failure of any active component (equipment or control device) shall not disable the fire protection system. Fire protection systems and components shall have fail-safe features and audible and visual alarms for operability and trouble indications.

An emergency source of electric power shall be provided to operate fire protection systems. Fire protection systems shall be capable of operating during a normal power outage. The emergency power sources and the electrical distribution circuits shall have independence and testability to ensure performance of their safety functions assuming any single failure.

The designers of the fire protection system shall consider the fire and explosion potential of the materials being processed and the solvents used during processing. In addition, the design shall include facility-specific fire protection systems to mitigate the damage from pyrophoric and other materials that are fire hazards, (e.g., magnesium, ion exchange resins, nitrate solvent and nitrate reduction reactions, and zirconium fuel element cladding hulls).

When the process uses or produces combustible gases or vapors, the design shall include features such as inert gas purging, premixing hydrogen to a nonflammable percent with inert gas, and increasing the air flow within process confinement barriers to provide the dilution required to maintain the concentration of gases or vapors below the lower limit for flammability.

Entry of air into furnaces operating with reducing gas shall be precluded by the use of inert-gas purged locks or other suitable means at the furnace entry and exit. Furnace gas shall be exhausted through a filtered exhaust system.

Process furnaces shall be provided with a system for automatically shutting off the furnace gas and purging with inert gas in the event of power failure, loss of coolant water, loss of exhaust ventilation, overtemperature, or detection of hydrogen in the vicinity of the furnace.

Automatic water sprinkler coverage shall be provided throughout the facility except in areas where nuclear criticality or other hazards specifically preclude its use or where Halon systems are required to reduce equipment damage.

The water supply for the permanent fire protection installation shall have a minimum of two reliable, independent sources each with sufficient capacity (based on maximum demand) for firefighting until other sources become available. Only time of these two sources shall be required to be DBE qualified.

To protect the integrity of process confinement systems. fire protection systems shall include the following features:

- Automatic and redundant fire detection devices
- A fire-extinguishing system to rapidly remove heat produced by fire to prevent or minimize the pressurization of a process confinement and to rapidly extinguish a fire to minimize the loading of ventilation system filters with combustion products
- The introduction of the extinguishing agent in a way that does not result in overpressurization of the confinement barriers

Where fire barriers are penetrated by the confinement system's ventilation ducting, fire dampers shall be appropriately used to maintain the barrier integrity. However, the closure of such dampers shall not compromise the functions of the confinement system where the loss of confinement might pose a greater threat than the spread of fire. In such cases, alternative fire protection means (e.g., duct wrapping) shall be used as a substitute for fire barrier closure. In no case shall a sprinkler system (including safety class sprinklers) be considered a fire barrier substitute.

Where the risk of uranium or plutonium metal fire is high, the operator shall be provided with a supplementary capability to extinguish a fire (e.g., dousing with carbon microspheres or magnesium oxide sand).

Because of flammable or potentially flammable atmospheres, electrical installations in hazardous process locations shall be designed to preclude the introduction of any ignition source by the electrical equipment.

1530-99.2 Emergency Preparedness Facilities

Emergency preparedness facilities containing telecommunication equipment, alarm transmission equipment, or ADP equipment shall be protected according to the criteria of 1530-99.8, Telecommunications, Alarm, and ADP Centers and Radio Repeater Stations.

1530-99.4 Explosives Facilities

The hazards from fire in buildings (except storage magazines) containing explosives and plutonium require the installation of automatic&e suppression systems. For buildings containing only explosives, fire suppression systems are required as dictated by DOE "improved risk" criteria and mission requirements. Additional protection, such as automatic deluge systems, shall be provided where appropriate. Advice and guidance shall be obtained from cognizant DOE fire protection personnel during the planning and design of explosives facilities to ensure that necessary protection is provided.

Where fire suppression is required, each explosives bay shall have an individual feed with controls protectively located outside the bay to remain operable in the event of an explosion in any bay. The design of the fire suppression systems shall comply with these criteria. Specific operations conducted on explosives shall be considered and fire protection features provided to mitigate unfit risk. In addition, early warning of fire shall be considered where such early warning might reasonably aid in prevention or mitigation of an accident.

Transmitted alarms shall distinguish between explosives and non-explosives areas through the use of annunciator panels at safe locations.

1530-99.8 Telecommunications, Alarm, and ADP Centers and Radio Repeater Stations

An automatic sprinkler system shall be provided in all centers where water availability is adequate based on engineering analysis. Systems should normally be wet pipe with smoke detection. Other automatic suppression systems such as halogenated fire extinguishing agent systems or carbon dioxide systems shall be supplementary only.

The fire protection system shall comply with DOE/EP 0108 and NFPA 75. All sprinkler systems should be hydraulically designed for the appropriate water density based on occupancy.

Automatic fire detection systems shall be provided in all centers. Each system shall provide for automatic alarm transmission to local sounding devices and to the cognizant fire alarm center.

The detection system shall perform the following functions:

- Initiate an alarm to the building alarm system and to the local fire alarm control center

- Shut off electric power to computer-electronic data processing equipment in those areas where fire may operate sprinkler heads before manual power shutdown could be accomplished

- Activate the appropriate HVAC system control sequence to provide smoke evacuation

A manual reset shall be provided to reenergize the interrupted electrical systems.

1530-99.12 Uranium Enrichment Facilities

1530-99.12.1 Gaseous Diffusion and Centrifuge Facilities

Storage areas for UF_6 and process areas handling UF_6 shall be physically isolated from other areas by fire-resistant barriers. In addition, UF_6 storage areas shall be protected by water sprinklers designed to keep the UF_6 area cool in case of fire.

Fire-resistant physical-isolation barriers shall be designed for both the fluorine gas storage area and process areas that use fluorine. All off-gas that can contain fluorine (or hydrogen fluoride) shall be scrubbed with a caustic (or equivalent) solution in a scrubber to reduce hydrogen fluoride, fluorine, and ozone (minor product resulting from reaction between fluorine and moisture) in the off-gas to less than the allowable EPA emission limits.

Jet exhausters and caustic- or soda-lime traps shall be provided to purge manifold pigtail connections.

Nitrogen shall be used as a fluorine system purge.

Fluorine and hydrogen fluoride monitors shall be provided at strategic points to detect and to cut off fluorine flow at the source (by self-activation of the monitor and positive shutoff valves).

1530-99.12.2 Atomic Vapor Laser Isotopes Separation Facilities

The laser dye areas of AVLIS facilities contain ethyl alcohol and shall be classified as hazardous locations according to Article 500 of the NEC. Electrical equipment and wiring shall meet the requirements for use in a Group D atmosphere.

Ethyl alcohol shall be confined to a closed system that prevents exposure to the atmosphere under normal operating conditions. The dye flow system shall be egregated into small flow loops with interlocked stop and shunt valves actuated by signals from flow, level, and pressure sensors.

1530-99.16 <u>Uranium Conversion and Recovery Facilities</u>

The fire protection provisions for UCRF shall meet the following requirements:

- Physical isolation barriers shall be designed for process areas that use hydrogen. Pressurized hydrogen gas storage areas shall be surrounded with fire-resistant barriers. The pressurized hydrogen storage tanks shall be capable of being isolated from the distribution system using positive shutoff valves. The distribution system shall either be double piped (pipe within a pipe) or have hydrogen detectors located at strategic points, with the detector-activated capability of shutting off hydrogen flow at the source.

- Fire-resistant, physical isolation barriers shall be designed for both the fluorine gas storage area and process areas that use fluorine. All off-gas that can contain fluorine (or hydrogen fluoride) shall be scrubbed with a caustic (or equivalent) solution in a scrubber to reduce hydrogen fluoride, fluorine, and ozone (minor product resulting from reaction between fluorine and moisture) in the off-gas to less than the allowable EPA emission limits.

- Jet exhausters and caustic- or soda-lime traps shall be provided to purge manifold pigtail connections.

- Nitrogen shall be used as a fluorine system purge.

- Fluorine and hydrogen fluoride monitors shall be provided at strategic points to detect and to cut off fluorine flow at the source (by self-activation of the monitor and positive shutoff valves).

- For a metal fire, water shall not be used except to keep the fire from spreading or as a last resort to save the facility. Effective extinguishing agents for small metal fires shall include inert gas in an enclosure, carbon microsphere for blanketing the burning metal, and magnesium oxide for blanketing the fire.

- All flammable materials shall be stored separately from one another and in-process inventories minimized.

- Sources of heat or ignition shall not be designed for inclusion near metal storage or holdup areas. Facilities fires shall be kept from spreading to metals, and fire-resistant barriers shall be designed into facilities to isolate metal storage areas.

1530-99.19 Tritium Facilities

The fire protection provisions for tritium facilities shall meet the following requirements:

- Consideration of unique fire sources (e.g., uranium traps used for tritium storage)
- Compatibility of fire extinguishing agents with the fire sources in a tritium facility
- Handling requirements for expended fire fighting agents that may become contaminated with tritium

1540 PLUMBING/SERVICE PIPING

1540-1 PLUMBING

1540-1.1 General

These criteria apply to interior plumbing systems (fixtures, supply, drain, waste and vent piping, service water heating system, safety devices, and appurtenances) up to 5 feet beyond the building exterior wall.

Domestic water shall be supplied by a separate service line and not be a combined fire protection and potable water service or a combined process water and potable water system within the building.

Plumbing shall comply with the NSPC (or other locally adopted nationally recognized plumbing code), ASHRAE Handbooks, and ASHRAE Standard 90.

Design criteria for special systems related to the facility process or research requirements shall be provided by the cognizant DOE authority.

Penetrations of piping through security barriers shall be minimized. Such penetrations more than 96 square inches in area and more than 6 inches in minimum dimension shall provide a penetration delay equal to that required for the security barrier. The physical attributes and intended service of the piping and the axial configuration of the barrier penetration shall be considered when evaluating that penetration delay.

1540-1.2 Fixtures

All fixtures shall comply with FS WW-P-541.

Fixtures and appurtenances suitable for usc by handicapped persons shall comply with Section 0110-8, Accommodations for the Physically Handicapped. Self-contained mechanical-refrigerated coolers shall be provided wherever a need for drinking fountains exists. Ratings shall be based on ARI 1010. Electrical equipment shall be UL listed.

1540-1.3 Piping

1540-13.1 Supply

Type K copper tubing shall be used below grade. Type L copper tubing shall be used above grade. CPVC and PB plastic pipe and tubing may be used in lieu of copper tubing above grade where not subject to impact damage or otherwise prohibited by DOE project criteria.

Fittings for Type K shall be flared brass, solder-type bronze or wrought copper. Fittings for Type L shall be solder-type bronze or wrought copper. Fittings for plastic pipe and tubing shall be solvent cemented or shall use other forms of joining (such as electric heat fusion) at the direction of the cognizant DOE authority or shall use Schedule 80 threaded. No lead solder shall be used for copper pipe in potable water systems.

Stop valves shall be provided at each fixture. Accessible shut-off valves shall be provided at branches serving floors or fixture batteries for isolation, or at risers serving multiple floors. Shut-off valves shall be provided to isolate equipment, valves, or appurtenances for ease of maintenance.

Accessible drain valves shall be provided to drain the entire system. Manual air vents shall be provided at high points in the system.

Provision for expansion compensation shall be included where thermal expansion and contraction cause piping systems to move. The movement shall be accommodated by using the inherent flexibility of the piping system as laid out, by loops, by manufactured expansion joints, or by couplings.

Accessible manufactured water hammer arresters shall be provided. Dielectric connections shall be made between ferrous and non-ferrous metallic pipe.

Where domestic or fire water service lines enter buildings, suitable flexibility shall be provided to protect against differential settlement or seismic activity in accordance with the NSPC or NFPA 13, respectively.

1540-1.3.2 Drain, Waste and Vent

Underground lines shall be service weight cast iron soil pipe hub-type (with gasket); hubless cast iron soil pipe may be used in locations where piping is accessible. Aboveground (above grade) lines that are 1-1/2 inch in diameter and larger shall be either hubles or hub-type (with gasket) service weight cast iron soil pipe, Lines 1-1/2 inch through 6 inch in diameter may be ABS or PVC plastic pipe where allowed by DOE project criteria. Pipe and fittings shall be joined using solvent cement or elastomeric seals. Lines smaller than 1-1/2 inch in diameter shall be either 1) Type L copper with solder-type bronze or wrought copper fittings or 2) galvanized steel with galvanized malleable iron recessed threaded and coupled fittings. Cast iron soil pipe fittings and connections shall comply with CISPI guidelines.

Provisions for expansion compensation shall be included as above.

1540-1.4 Service Water Heating Equipment

The service water heating system shall provide flow within 10 seconds of approximately 110°F at the most remote outlet from generation equipment, except where this is deemed unnecessary by the cognizant DOE authority.

Booster heaters shall be provided where sanitizing for dishwashing or where a temperature above the normal water heater outlet temperature is required.

Generation equipment and system selection shall be based on LCC analysis and available energy sources.

1540-1.5 Safety Devices

Tempering valves shall be the fail-safe pressure balance type.

As directed by project criteria, emergency eye washes, emergency showers, or combination emergency eye wash-showers shall be provided in areas where corrosive or other skin or eye irritant chemicals are stored, handled, used or dispensed. Equipment shall comply with ANSI Z358.1 and be serviced by the potable water system.

Hot water generation equipment shall be provided with ASME code-stamped tanks, when of sufficient capacity, water temperature, or hot input rate to be within the jurisdiction of the ASME Boiler and Pressure Vessel Code. Approved relief devices, combination temperature-pressure or separate units, depending on the application, shall be provided.

Backflow preventers and air gaps shall be used to prevent cross-connection (contamination) of potable water supplies. Vacuum breakers (to prevent back-siphonage) shall be used only in conjunction with administrative controls.

1540-1.6 Appurtenances

1540-1.6.1 Pressure Modification

Pressure-reducing valves shall be provided where service pressure at fixtures or devices exceeds the normal operating range recommended by the manufacturer.

Wherever a pressure-reducing valve's failure may cause equipment damage or unsafe conditions, a pressure-relief valve shall be provided downstream of the reducing valve.

A means to increase the system water pressure shall be provided when incoming water service pressure will provide less than the minimum operating flow and pressure recommended by the manufacturer.

The basic pressure-boosting system should be a manufactured package composed of an ASME-rated hydropneumatic, non-rechargeable tank, multiple alternating pumps, and low-flow/demand tank operation (without pump). Manufactured packages shall include all required operational and safety features.

Booster system pressure-flow requirements shall be based on existing water main hydraulic data, static pressure, and residual pressure at flow, at the approximate anticipated tap-in connection point. The cognizant DOE authority shall provide this information to the design professional.

1540-1.6.2 Water Treatment

The cognizant DOE authority shall provide the design professional with current water quality analysis data on which to base the method of water treatment, if needed.

The system shall be selected on an LCC basis considering equipment first cost, operating and maintenance costs, and chemical cost.

1540-1.6.3 Trap Seal Protection

A trap primer valve and floor/funnel drain with trap primer valve discharge connection shall be used where there is the possibility of the loss of the seal in floor/funnel drain traps.

1540-1.6.4 Hose Bibbs, Wall Hose Outlets, and Yard Hose Outlets

Project criteria shall indicate number, location and preferred type of hose bibbs and hydrants. All units served by potable water systems shall have integral vacuum breakers, and in addition, administrative controls in the form of signs and scheduled maintenance testing of vacuum breakers.

1540-1.6.5 Insulation

See Section 1525, Mechanical Insulation.

1540-1.6.6 Sterilization

New supply systems or rehabilitation to existing supply systems shall require sterilization as per AWWA C652, AWWA C5186, or local governing plumbing code.

1540-1.6.7 Miscellaneous

Access panels shall be provided where maintenance or replacement of equipment, valves, or other devices are necessary.

Escutcheons shall be provided at wall, ceiling, and floor penetrations of piping in occupied areas.

1540-99 SPECIAL FACILITIES

1540.99.0 Nonreactor Nuclear Facilities-General

1540-99.0.1 General Coding System Criteria

These criteria and requirements are for cooling water and water supply systems including all components that transfer heat from sources in the facility to the ultimate heat sink that are classified as safety class items in accordance with Section 1300-3.2, Safety Class Items. The function of the safety class water system is to provide a sufficient quantity of water to satisfy the safety needs of the following:

- Cooling systems that remove heat from storage pools or process vessels that contain radioactive liquids

- Cooling needs of other equipment or systems requiring a supply of water to perform their safety functions

Water systems shall be designed to incorporate sufficient redundancy and independence to ensure that served systems and structures are adequately cooled and that adequate emergenq supplies of water are available during normal operations, anticipated operational occurrences, and DBA conditions with the addition of a single failure of a component in the water system.

The cooling water system shall have a heat utilization capability at least equal to the maximum heat load imposed under any mode of normal operations, anticipated operational occurrences, and DBA conditions.

The water supply system shall be capable of supplying the long-term water needs of a facility following a loss of normal water supply or other accident.

The water system shall be designed to a national piping code (i.e., ASME Boiler and Pressure Vessel Code, Section III or ASME B31.3). The design of systems that must provide cooling water following a DBE shall include the forces resulting from a DBE.

The cooling water system shall be provided with at least two source of motive power.

The water system design shall include provisions for isolating leaking components such as heat exchangers.

Adequate instrumentation and controls shall be provided to assess water system performance and allow the necessary control of system operation.

Components of the water system that are powered by electricity only shall be considered as safety class loads.

As required to provide necessary cooling, the water system and the ultimate heat sink shall be protected against the effects of severe natural phenomena and man-made events.

Equipment in the cooling water system shall be appropriately qualified to ensure reliable operation under normal operations, anticipated operational occurrences, and DBA conditions.

The design of cooling and water supply systems shall require the following:

- The performance of initial and periodic hydrostatic tests to verify system integrity
- The performance of periodic operational tests of system performance
- In-service inspection of system components

Pumps, valves, filters, and other components associated with cooling and water supply systems shall be readily accessible for maintenance.

System redundancy requirements include the following:

- The cooling system shall be composed of at least two water sources, each capable of performing the necessary safety functions, unless it can be demonstrated by safety analysis that there is an extremely low probability of losing the capability of a single source.
- Where conduits and pumps are required as a part of the cooling system, the use of at least two complete delivery systems shall be considered.

Means shall be provided to detect and control leakage of radioactive material into the coolant. The consequences of such leakage shall not significantly degrade system performance or endanger personnel.

Leakage of coolant into waste storage vessels shall be detectable, and the volume of coolant that may enter the waste tank shall be controlled to prevent overflow.

To the extent practicable, all coding system components shall be accessible during all operating modes.

1540-99.0.2 Water Collection System

Collection systems shall be provided for water runoff, such as from firefighting activities, from areas within special facilities containing radioactive material. Nuclear criticality prevention (if necessary), confinement, sampling, volume determination, and retrievability of liquids and solids shall be provided for in the design of collection systems. The size of the collection system for firefighting water shall be based on the maximum amount of water that would be collected in fighting the DBF. The configuration of the system components shall be based on conservative assumptions as to the concentration of fissile or other materials capable of sustaining a chain reaction that might collect in the system. Recirculating systems shall also be considered when there is no possibility of contamination.

For facilities that process, handle, or store fissile or other material capable of sustaining a chain reaction, the water runoff collection system shall be designed with the following nuclear criticality safety considerations:

- The maximum material mass loading that could be in the runoff system

- The most disadvantageous material concentrations, particle size, and material dispersion in the water slurry

- The change in concentration of material and geometric configuration of the slurry as the particulate matter settles out of the water

1540-99.0.3 Other Collection Systems

Consideration shall be given to the collection and monitoring of radioactive and nonradioactive contaminants in natural runoff (e.g., roof drainage) and blowdowns from heating and cooling systems before discharge to the environment.

Safety shower water and personnel decontamination shower water shall drain to the contaminated process water waste system.

1540-99.0.4 Equipment Operability Qualification

Testing or a combination of testing and analysis shall be the preferred method of demonstrating the operability of fluid system components, mechanical equipment, instrumentation, and electrical equipment that are required to operate during and following a DBE. Seismic experience data may be used as an alternative to testing or dynamic analysis where such data have been documented and validated.

1540-99.0.5 Water Supplies and Other Utility Services

On-site water supplies and other utilities shall be provided as necessary for emergency use. The design of each utility service or coding water system shall consider the demands for normal operations, anticipated operational occurrences, and DBA conditions.

1540-99.0.6 System Installation

The following design features represent recommended practices for the installation of piping and valves carring hazardous process fluids. In addition, the design professional shall consider the applicability of the criteria in R.G. 8.8 for piping systems carrying radioactive materials.

- Pipe and valve locations as specified on approved drawings (not located at the discretion of the installer)

- Valves designed and installed to operate in the stem-up orientation

- Valves and other connections located to minimize the consequences of leaks

- Block valves in pipes that enter or exit a process area

- Piping not embedded in concrete slabs

- Pipe sleeves where piping passes through nonshielding concrete walls, floors, and roofs

- Sleeves sloped to drain toward the controlled area
- Space between the pipe and sleeve to be packed and sealed
- Process valves not located at low points in the piping
- Corrosion resistance of block valve and/or check valve and associated process piping equivalent and adequate
- Welded joints rather than flanged connections wherever possible; butt-welded joints rather than socket-welded joints

1540-99.4 Explosives Facilities

1540-99.4.1 Drains and Sumps

All drain lines handling explosive wastes shall be provided with sumps or basins of adequate design and capacity for the removal of explosives by settling. The drains shall be of adequate capacity, free of pockets, and have sufficient slope (at least 1/4 inch per foot) to prevent the settling out of explosives in the line until it reaches the sump or settling basin.

Drain gutters within buildings may be constructed with a slope of 1/8 inch per foot. However, a satisfactory program of cleaning must be developed to ensure that all hazardous material is removed from drain gutters.

Sumps must be designed so that suspended solid explosive material and solid explosive material capable of settling out cannot be carried in the wash waters beyond the sumps. The design shall allow sufficient settling time on the basis of the settling rate of the material and the usual flow rate. The sump shall be constructed so that the overflow will not disturb any floating solids. The design must also allow easy removal of collected explosives that float on water (until it can be skimmed off).

Explosives collection trays for sumps shall be constructed of nonferrous metal. Hoisting equipment used for lifting the trays shall be designed to prevent the trays from binding on the sides of the sump. Bolted sump tanks or other types of construction that allow the explosives to settle in obscure or hidden spaces are prohibited.

Drains between the source of explosives and the sump shall be troughs with rounded bottoms and removable ventilated covers to facilitate inspection for accumulation of explosives. Short sections of closed pipe or trough are acceptable if they can be visually inspected for blockage or explosives buildup. Explosives or explosive-contaminated waste liquids shall not be run into closed drains and sewers.

Drains containing explosive waste materials must not be connected in a manner to empty such wastes into the normal sewage systems carrying inert or sanitary wastes. Wastewater that might contain explosives materials shalt be kept from contaminating potable water or conventional wastewater systems. If pumping is involved in removing the settled explosives from a slurry settling tank, the operation shall be arranged to preclude exposure of the explosive material to any pinching in the operation.

Care must be taken to avoid the possibility of deposition of explosives from sump effluent due to drying, temperature changes, or interaction with other industrial contamination. When explosives that are appreciably soluble in water are handled, sweeping and other dry collecting measures shall be used to keep it out of the drainage system.

The combination of sumps, settling ponds, etc., must remove explosives so that outflows (if allowed) meet environmental standards.

1540-99.12 Uranium Enrichment Facilities

UEF require cooling systems to remove the heat of compression from UF_6 in the process system and to liquefy UF_6 at product, tails, and withdrawal stations. This cooling is accomplished by a compatible coolant (e.g., Freon) in an intermediate loop between the process equipment and a cooling water system that transfers the heat to an ultimate heat sink.

UEF cooling systems are not generally required to be designed as safety class systems because their continued operation is not essential for protecting the health and safety of the public. Corrective actions or automatic protective actions may, however, be required to ensure the integrity of the process equipment (primary confinement) boundary following transients associated with the cooling system.

1540-99.14 Irradiated Fissile Material Storage Facilities

An IFMSF (water pool type) requires a safety class cooling water system, unless there is a safety class emergency source of makeup water to the storage pool and it can be demonstrated that, under emergency conditions, the pool structure can withstand the stresses imposed by loss of cooling and other considerations addressed in Section 1320, Irradiated Fissile Material Storage Facilities.

To the extent practicable, passive cooling means shall be used at dry storage facilities. If a cooling water jacket or air system is provided to ensure an acceptable temperature of stored material within the dry type storage facility, it shall be designed as a safety class system.

A safety class emergency makeup water system shall be provided when the cooling water system is not designed as a safety class system.

1540-99.15 Reprocessing Facilities

A cooling system shall be provided as a heat sink for heat removal from high-level liquid waste handling and storage systems.

1540-99.18 Radioactive Solid Waste Facilities

Facilities and equipment associated with the interim storage or treatment of high-level radioactive solid waste shall require a safety class water cooling system to remove decay heat from the waste and to ensure the long-term integrity of the primary confinement boundary.

Other radioactive solid waste facilities, including a high-level radioactive solid waste repository, do not generally require a safety class cooling system.

1550 HEATING, VENTILATING AND AIR-CONDITIONING SYSTEMS

1550-1 GENERAL SIZING AND DESIGN CRITERIA

1550-1.1 General Selection Procedures for HVAC Systems

The design professional shall evaluate building HVAC systems and sub-systems and select major HVAC equipment components based on a consideration of health and safety requirements, initial costs. operating costs, and maintenance costs according to the procedures listed in 0110-12.7, Building Design Analysis.

HVAC equipment shall be sized to satisfy the building heating and cooling load requirements and to meet all general equipment design and selection criteria contained in the ASHRAE Fundamentals handbook, ASHRAE Equipment handbook, ASHRAE Systems handbook, ASHRAE Applications handbook, and ASHRAE Refrigeration handbook. Calculations and equipment selection shall be made according to the procedures given in ASHRAE GRP 158 and appropriate chapters of the ASHRAE Fundamentals handbook.

1550-1.2 Heat Gain and Heat Loss Calculations

1550-1.2.1 Building Envelope Thermal Transmittance ("U") Values

See Section 0110-12.3, Building Envelope Thermal Transmittance Values, for criteria to be applied in building planning and design.

1550-1.2.2 Inside Design Temperature and Relative Humidities

Environmental design temperatures and relative humidities for special space uses other than those listed here shall be designated in the project criteria. The design professional shall verify that the recommended design values are within the criteria bounds of ASHRAE Standard 55 and that the values are within energy conservation criteria guidelines as stated in Section 0110-12, Energy Conservation. The design professional shall alert the cognizant DOE authority if the recommended DOE design values will result in energy inefficiency or occupant discomfort.

When space cooling is required, the inside design temperature to maintain personnel comfort shall be 78°F dry bulb unless otherwise indicated by project criteria. The design relative humidity shall be 50 percent. Summer humidification shall not be provided for personnel comfort. Cooling systems shall be designed to maintain space relative humidity conditions through the normal cooling process and should not have controls to limit the maximum relative humidity unless project specific criteria dictate.

See Section 1550-1.4, Use of Evaporative/Adiabatic Cooling, for inside design temperature and humidity conditions applicable for adiabatic cooling systems.

The inside wintertime design temperature for personnel comfort shall be 72°F dry bulb unless otherwise indicated here or directed by the project criteria. The following design temperatures shall be used for the space usages indicated in Table 1550-1.2.2.

Table 1550-1.2.2 Inside Design Temperatures

Temperature (°F db)	Space
As indicated by DOE project criteria	Storage (unoccupied)
55°	Storage (occupied)
50°	Warehouses
60°	Kitchens
65°	Laundries
65°	Shops (high work activity)
70°	Toilets
75°	Change Rooms (heating only when occupied)

Except where it can be substantiated from recordings or engineering computations that the inside relative humidity will be less than 30 percent, winter humidification for personnel comfort and health shall not be provided. Where such renditions have been substantiated, a design relative humidity of 30 percent shall be used in establishing minimum humidification equipment requirements.

1550-1.2.3 Outside Design Temperatures

The design professional shall design the HVAC system equipment using outside design temperatures as indicated in Table 1550-1.2.3 for the particular application. The percentage dry bulb (db) and wet bulb (wb) temperatures refer to the sources of tabulated weather data described in Section 1550-1.2.5, Weather Data. Where data for a particular location are not listed, design conditions shall be estimated from data available at nearby weather stations or by interpolation between stations, taking into account elevation and other local conditions affecting design data.

1550-1.2.4 Infiltration Calculations

Infiltration for heating and cooling design loads shall be calculated according to the methods provided by ASHRAE Publication GRP 158 and the ASHRAE Fundamentals handbook.

1550-1.2.5 Weather Data

Weather data for use in sizing HVAC equipment shall be obtained from one or more of the following:

- Local weather station

Table 1550-1.2.3 Outside Design Conditions

Winter	Summer	Application
99% db	1% db and mean coincident wb	Process, laboratory and other uses where close temperature and humidity control is required by project criteria.
97-1/2% db	2-1/2%db mean coincident wb	Personnel comfort systems
--	1% wb	Cooling towers* and research, technical-type systems
--	1% db plus °F	Air-cooled condensers*

*Temperature should be verified by actual site conditions.

- AFM 88-29
- "Climatic Conditions for the United States," ASHRAE Fundamentals handbook
- National Climatic Data Center, NOAA, Federal Building, Asheville, North Carolina 28801

1550-1.3 Heating and Air-Conditioning Equipment Sizing and Performance

The capacity of central heating, refrigeration, and ventilation equipment shall be sized for the peak block building or the maximum simultaneous zone heating and cooling design loads and in accordance with the ASHRAE Fundamentals handbook. The equipment shall not be sized for future additional capacity nor redundancy unless indicated in DOE project criteria. Individual zone equipment shall be sized according to the peak zone load. The requirements of ASHRAE Standard 62 concerning minimum outside air requirements shall also be considered during the sizing process.

All HVAC equipment shall meet the performance and efficiency standards of ASHRAE Standard 90, Section 6.

Thermal storage systems shall be considered according to the requirements of 0110-12.7, Building Design Analysis, when required by DOE project criteria.

1550-1.4 Use of Evaporative/Adiabatic Cooling

In locations where a wide variation exists between the dry and wet bulb temperatures for extended periods of time, evaporative/adiabatic cooling shall be considered for the applications listed below. Selection of cooler types shall depend on the system configurateion, user experience, and LCC analysis. All evaporative coolers shall maintain a positive water-bleed and water-makeup system for control of mineral buildup.

Applications that shall be considered include warehouses, shops not requiring close (plus or minus 5°F) temperature control, non-residential size kitchens, makeup air ventilation units, and mechanical equipment spaces.

Air duct design, number and location of coolers, and relief of the higher rate of air supply to the atmosphere shall be considered to ensure a satisfactory operating system. Multi-stage evaporative cooling systems shall also be considered.

For shops and similar large open bay areas, the heating and cooling systems shall not be combined except where it is economically or operationally justified. Two-speed fan operation shall be used: feet speed and higher cfm air flow rate during the cooling cycle and slow speed and lower cfm air flow rate during the heating cycle. Where the difference between heating and cooling air flow requirements is too great to allow for adequate air outlet device performance at the lower air flow requirement, separate heating and cooling systems shall be provided.

Indoor design dry bulb temperatures for spaces air-conditioned by adiabatic cooling systems shall be as specified by project-specific criteria. Design operating efficiency of adiabatic cooling equipment shall be a minimum of 70 percent. System-installed capacity shall be based on the conditioned space peak design cooling load. An arbitrary air-change rate for design air flow shall not be used. Adiabatic cooler specifications shall be stated in terms of the air capacity and the entering ambient dry and wet bulb temperatures and leaving dry bulb temperature.

1550-1.5 Ventilation-Exhaust Systems Design Reqirements

1550-1.5.1 General

The design professional shall select ventilation-exhaust systems for the effective removal of noxious odors, hazardous gases, vapors, fumes, dusts, mists, and excessive heat and for the provision of fresh air to occupants. The design criteria contained in this section shall be followed in determining the required air quantity and quality for ventilation and exhaust systems. Further design criteria are contained in Section 1550-2.5, Air Handling and Air Distribution System; Section 1550-99, Special Facilities, Section 1550-3, Testing, Adjusting and Balancing; Section 1595-6, Control of Air Handling Systems; NFPA 90A; and NFPA 91.

The use of exhaust stack(s) shall be considered to provide dispersion and preclude exhaust-to-intake return of air to this or an adjacent facility. Local weather and site conditions along with guidance found in ASHRAE Fundamentals shall be used to determine requirements.

1550-1.5.2 Outdoor Air Quality

Outdoor air shall be used to provide makeup air, dilute non-toxic contaminants and provide acceptable indoor air quality in spaces served by ventilation systems. The outdoor air shall meet the quality required by ASHRAE Standard 62. DOE project criteria shall include test data on ambient air quality. If the outdoor air does not meet the ambient air quality standards for particulate, gases, or other contaminants, it shall be treated to remove particles and gases and vapors as required to meet the minimum ambient air quality standards.

1550-1.5.3 Personnel Ventilation Air Requirements

The outdoor air shall be provided in the quantities indicated for conditioned offices and other occupied spaces in ASHRAE Standard 62. Outdoor air in addition to the quantities required by ASHRAE Standard 62 shall be provided when required to balance a building's or space's exhaust air rate or to maintain the building or space under a positive pressure. Proper ventilation rates shall be demonstrated by calculation if natural ventilation or infiltration is used as the outdoor air introduction method.

Special attention shall be given to design of ventilation systems where smoking will be allowed. For these spaces, the outside air ventilation rate designated for smoking areas by ASHRAE Standard 62 shall be provided or the appropriate air cleaning used.

1550-1.5.4 Recirculation

When air is supplied to a space, the portion of the total supply air that exceeds the required outdoor air quantity shall be recirculated through the ventilation system except from areas in which recirculation is specifically prohibited. If the indoor air quality does not meet or exceed the limits given in ASHRAE Standard 62, the recirculated air must be treated and monitored.

Areas from which air shall not be recirculated include areas that produce or emit dust particles, heat, odors, fumes, spray, gases, smoke, or other contaminants that cannot be sufficiently treated and could be potentially injurious to health and safety of personnel or are potentially damaging to equipment. These areas shall be 100-percent exhausted. Project criteria shall indicate other areas of non-recirculation.

Ventilation and exhaust air systems serving these areas or other special areas shall meet all the deliverable-air quantity requirements of ASHRAE Standard 62 and any other specific equipment requirements as discussed in Section 1550-2.5, Air Handling and Air Distribution Systems, and Section 1550-99, Special Facilities.

Rest rooms, janitor's closets, garbage rooms, and other malodorous spaces shall be exhausted at a rate of not less than 2 cfm per square foot or as specified in ASHRAE Standard 62, whichever is the more stringent, regardless of any other calculated ventilation requirements. Space ventilation air from adjacent spaces should be used as the ventilation supply air for the 100-percent exhausted spaces, as long as:

- Ventilation by this method does not violate any requirements of NFPA 90A, NFPA 101, or special space pressurization requirements
- The air supplied is not potentially more hazardous than the air from the space exhausted

1550-1.5.5 Industrial Ventilation Requirements

Industrial-type facilities and laboratories shall be provided with ventilation (supply and exhaust) systems as required for heat exposure comtrol, or dilution ventilation. Ventilation air shall be provided in the quantities required to maintain OSHA air quality limits, all the PELs established by 29 CFR 1910 and all ACGIH TLVs. Design air quantities and transport velocities shall be calculated according to the calculation methods prescribed by the

ASHRAE Systems handbook, the ASHRAE Applications handbook, the ACGIH Industrial Ventilation Manual, 29 CFR 1910, and NFPA 45. Designers shall consider ASHRAE Applications Chapter 14, “Laboratories,” when designing laboratories and laboratory buildings. Makeup air shall be provided in the quantities required to maintain requirded positive or negative room static pressure requirements and to offset local exhaust air quantities. Makeup air shall be tempered.

1550-1.5.6 Local Exhaust Systems

DOE project-specific criteria shall provide information on the source, quantity, and type of contaminants. Local exhaust systems shall be designed to maintain the required capture air velocities for source contaminant control. Air quantities and transport shall be calculated based on the calculation methods prescribed by the ASHRAE Systems handbook, the ASHRAE Applications handbook and the ACGIH Industrial Ventilation Manual. Further design criteria for local exhaust systems are contained in Section 1550-2.5, Air Handling and Air Distribution Systems, and Section 1550-99, Special Facilities.

1550-1.5.7 Equipment Room Ventilation

Mechanical and electrical equipment rooms shall be exhausted so that room temperature does not exceed NEMA equipment ratings. DOE project criteria shall provide the space temperature limit criterion. Where mechanical ventilation cannot maintain a satisfactory environment, evaporative cooling systems or other mechanical cooling systems shall be provided. Exhaust air openings should be located adjacent to heat-producing equipment to minimize ambient thermal loads.

Thermostatic controls shall be used to operate the ventilation or exhaust systems as discussed in Section 1595, Controls.

Equipment rooms containing refrigeration equipment shall be ventilated in accordance with ASHRAE Standard 15.

Combustion air for fuel-burning appliances and equipment shall be provided to all equipment rooms with this type of equipment in accordance with BOCA Basic/National Mechanical Code.

1550-1.6 Energy Conservation-Waste Heat Recovery Systems

Specific energy-efficient features and waste heat recovery systems for all types of heating, ventilating, and air-conditioning equipment shall be considered according to the methods prescribed in Section 0110-12.7, Building Analysis Procedures, and in Section 1550-1.1, General Selection Procedures for HVAC Systems. Special consideration shall be given to energy conservation systems if they affect health and safety, for example, corrosiveness of exhaust air to heat recovery coils.

Energy conservation-waste heat recovery systems shall be considered and designed according to the procedures outlined in specific chapters of the ASHRE Fundamentals handbook, the ASHRAE Systems handbook, the ASHRAE Applications handbook, ASHRAE Equipment handbook, ASHRAE Refrigeration handbook, and the SMACNA Energy Recovery Equipment and Systems Manual.

The following types of heat-recovery systems shall be considered for incorporation into the building HVAC system design where applicable:

- Use of rotary heat exchanger, heat pipe, or coil run-around systems for heating and air-conditioning air handling systems with more than 4000 CFM of outside ventilation-exhaust air
- Recovery of rejected heat from the condenser systems of central station cooling equipment for use in heating the remainder of the building when the central station cooling equipment must operate during the heating season to cool computer rooms, high internal heat gain areas, or process requirements
- Use of thermal heat from the condenser systems of kitchen or other continuously operated refrigeration equipment for space heating or domestic hot water heating when the rejected heat from the equipment is greater than 35,000 BTUh
- Use of a free cooling system using cooling tower water (water side economizer) when air-side economizer systems are not feasible
- Use of a heat pump run-around loop

These evaluations shall be included in the "Energy Conservation Report" detailed in Section 0110-12.8, Energy Conservation Report Requirements.

1550-2 HEATING VENTILATING AND AIR-CONDITIONING SYSTEMS SELECTION

1550-2.1 <u>Central Station Cooling Equipment and Systems</u>

1550-2.1.1 General

Selection of central station cooling systems shall be based on the LCC analysis procedures outlined in Section 0110-12.7, Building Analysis Procedures. Size, selection and design shall be based on ASHRAE Fundamentals handbook, ASHRAE Systems handbook, ASHRAE Applications handbook, and ASHRAE Equipment handbook. Refrigeration equipment shall comply with ARI 520, ARI 550, and ARI 590.

Central chilled water plants shall be considered where two or more adjacent buildings are to be air-conditioned. The number and size of central station cooling units shall be based on the annual estimated partial-load operation of the plant to assure the most economical operation.

DOE project design criteria shall provide direction on installed standby chiller capacity. The design professional shall consider the use of multiple chillers for all chilled water loads greater than 400 tons. Wherever possible, the central station chilled water equipment shall be designed into the chilled water distribution systems as part of a primary-secondary loop system maintaining chilled water inlet temperature below a maximum predetermined value, preferably with the central station cooling equipment as a secondary portion of the loop.

Temperature-critical areas, as determined by project criteria, such as laboratories and computer centers, shall be provided with independent refrigeration systems with backup systems if involved with vital programs. The design professional shall consider use of off-peak cooling systems in areas having high electric peak demand charges.

1550-2.1.2 Water Chillers

The selection of either centrifugal, reciprocating, helical, rotary-screw, absorption, or steam-powered chillers shall be considered based on coefficients of performance at full load and part-load conditions using the LCC methods as described in Section 0110-12.7, Building Analysis Procedures. The LCC analysis shall also consider chilled water and condenser water system pumping energy burdens as part of the evaluation. Compression refrigeration machines shall be designed with the safety controls, relief valves, and rupture disks noted below and in compliance with the procedures prescribed by ASHRAE Standard 15 and UL 207. Controls shall at a minimum include:

- High discharge refrigerant pressure cutout switch
- Low evaporator refrigerant pressure or temperature cutout switch
- High and low oil pressure switches
- Chilled water flow interlock switch
- Condenser water flow interlock switch (on water cooled equipment)
- Chilled water low temperature cutout switch

Centrifugal compressors shall be designed to operate with inlet vane control or variable speed control for capacity modulation. Units shall be capable of modulating to 20 percent of design capacity without surge. Reciprocating compressors shall be designed for capacity control by cylinder unloading. Design using hot gas bypass control of compressors for capacity modulation shall not be used except when capacity modulation is required below 10 percent of rated load. Compressor motors for refrigeration equipment shall be selected in compliance with all requirements of the NEC.

Absorption refrigeration machines shall at a minimum be provided with the following safety controls:

- Condenser water flow switch
- Chilled water flow switch
- Evaporation refrigerant level switch
- Generator high temperature limit switch (gas-fired units)
- Generator shell bursting disc (high temperature water or steam)
- Concentration limit controls

Liquid coolers (evaporators) shall be designed to meet design pressure, material, welding, testing and relief requirements of ASHRAE Standard 15 and ASME Boiler and Pressure Vessel Code, Section VIII. The design professional shall select evaporators according to the requirements of ASHRAE Standard 24-78.

The design professional shall select chilled water system temperature controls according to the procedures described in Section 1595-7, Control of Chilled Water and Hot Water Distribution Systems.

1550-2.1.3 Condensers/Condensing Units

Water cooled condensers shall comply with ASHRAE Standard 15 and ASME Boiler and Pressure Vessel Code, Section VIII. The design professional shall select condensers based on the cooling factors recommended in ARI 450. Water-cooled condenser shell and tube types shall be designed and specified with removable heads, if available, to allow tube cleaning.

Air-cooled condensers and condensing units shall meet the standards, rating, and testing requirements of ARI 460 and ASHRAE Standard 20. Unless project-specific criteria dictate otherwise, these units shall not be located on roofs. The design professional shall locate air-cooled condenser intakes away from any obstructions that will restrict the air flow and from locations that receive peak solar heat gain. Air-cooled equipment shall be located away from noise-sensitive areas, and air-cooled condensers shall have refrigerant low head pressure control to maintain satisfactory operation during light loading.

1550-2.1.4 Cooling Towers

The design professional shall locate and place cooling towers to avoid problems with water drift and deposition of water treatment chemicals. Unless project-specific criteria dictate otherwise, towers shall not be located on roofs. Cooling towers shall have ample clearance from any obstructions that would restrict air flow, cause recirculation of discharge air, or inhibit maintenance.

The design professional shall specify cooling tower acceptance and factory rating tests conducted in accordance with CTl Bulletin ATC-105.

An automatic-controlled water bleed shall be designed for all coding towers. A cooling tower water treatment program should be selected by a specialist. Cooling tower components shall be selected to prolong cooling tower life by use of neoprene-fiberglass fill and one of the following:

- Chemical treatment of tower members constructed of wood to form a coating insoluble in water
- Pressure treatment of the tower members constructed of wood with chemicals that are toxic to the organisms that cause wood decay
- Use of noncorroding ceramic, plastic, and metal components instead of wood

Cooling towers shall be specified with sump water heating systems if they will operate during freezing weather conditions.

1550-2.2 Central Station Heating Equipment and Systems

1550-2.2.1 General

This section applies to heat-generating equipment or heat-transfer equipment and accessories located in individual buildings. Information on central plant heat-generation equipment serving several buildings is contained in Section 1555, Central Plant Heat Generation/ Distribution.

A building heat generation system shall not be provided unless one the following conditions exists:

- Connection to the central plant distribution system is not cost effective
- The central plant has insufficient capacity to accept the building load
- The use of the building precludes connection to a potentially interruptible central system

DOE project criteria shall direct the design professional regarding factors to be considered in the selection of beating system capacity, including redundancy, future expansion or building modification, thermal storage or solar assistance, or other project-specific considerations. If maintaining building design temperature is critical, the design professional shall design for a "stand alone" heating system with backup capability with no dependence on other facility systems.

1550-2.2.2 Interfacing with Central Plant Heat Generation/Distribution Systems

Where buildings are connected to the central plant heat generation/distribution system, one of the following shall be provided:

- Steam-to-building hot water heat exchanger
- HTW-to-building hot water heat exchanger
- Steam-pressure-reducing station

Where appropriate a pressure-reducing (back-pressure) turbine shall be considered in accordance with DOE 4330.2C.

For space heating by hot water, conversion of the central heating plant steam or HTW shall be made to provide a maximum 200 °F heating-water supply temperature to serve the building terminal units. For spare heating by steam, the building steam supply shall be reduced to 15 psig unless a higher supply is required for process requirements.

For process-related or other high temperature requirements, the DOE project criteria shall indicate the capacities and temperature and pressure requirements.

For facilities with a central plant condensate return system, a condensate receiver with duplex pumps shall be specified.

Steam-to-hot water or HTW-to-building heating water converters shall be selected based on design criteria contained in ASHRAE Systems handbook, ASHRAE Applications handbook and ASHRAE Equipment handbook.

1550-2.2.3 Building Heat Generation Equipment/Distribution Systems

The design professional shall consider the use of direct and indirect gas-fired units, electric heating, heat-pumps (air-cooled and water-cooled), low temperature gas infrared heating, and hot water radiant heating and hot water distribution to terminal units depending on the building type, the DOE facility preference, and LCC. Office buildings or buildings with occupants sitting near fenestration shall be designed with perimeter finned-tube radiation heating systems or other perimeter heating systems. If the optimum heating system selected includes a hot water or steam distribution system and the heating medium is generated within the building and distributed to terminal units, the following requirements shall be met:

- Hydronic or steam boilers shall be selected based on LCC analysis considering fuel availability, boiler construction (e.g., steel or cast iron), space availability, and cognizant DOE authority preferences.

- Two or more boilers shall be provided, with the proportion of load each handles to be determined based on energy, redundancy and maintenance requirements (suggested proportioning 70 percent and 30 percent) and with staging of boilers, internal heating steps, and boiler sequencing as discussed in Section 1595-7.4, Load Control for Hot Water Systems.

- If the selected fuel is fuel oil, underground storage tanks installed in accordance with national, state, and local EPA regulations shall provide for 30 days of full beating capacity. Tank shall be fully trimmed for safety and operating conditions and shall include a remote level gauge. Tank shall comply with NFPA 30 requirements.

1550-2.3 Water Distribution Systems

1550-2.3.1 General

The design professional shall select chilled water, hot water, condenser water, boiler feed, and condensate return systems designed for economical pipe sizes based on allowable pressure drop, flow rate, and pump selection criteria as prescribed by the ASHRAE Fundamentals handbook, ASHRAE Equipment handbook, and ASHRAE Systems handbook, ASHRAE Applications handbook. Insulation shall be provided on all water distribution piping and system components. Strainers shall be provided at the suction side of each pump and each control valve. The design professional shall specify flexible connectors to be installed on the suction and discharge piping of base-mounted end suction type pumps.

Water distribution systems shall comply with the requirements of Section 0266-1, General, regarding location markers and cross-connections between distribution systems.

Check valves and balancing valves or combination check-shut-off-balance valves shall be installed in the discharge piping of all pumps operating in parallel pumping systems. Balancing valves shall be installed in the discharge piping of solitary pump systems.

Service valves shall be installed in the suction and discharge piping of all major pieces of equipment. Balancing valves shall be provided in the discharge piping of all coils, and central station cooling equipment.

Air elimination pressure control, venting, and automatic filling system (with backflow prevention) shall be provided for each hot water and chilled water distribution system, including provision of water treatment injection if required.

Expansion or compression tanks and fill piping connections shall be located on the suction side of the distribution system pump or pumps. Expansion tanks and air separation devices shall be sized according to the methods in the ASHRAE Systems handbook and specified in accordance with the requirements of ASME B31.1. Gauge glasses, drain valves and vent valves shall be provided for all expansion tank systems.

Water treatment design information for chilled water, hot water, and boiler feed water systems shall be provided by a specialist based on project criteria (tested water condition).

1550-2.3.2 Pumps and Pumping Systems

Pumps for chilled water, hot water, condenser water, boiler feed-water and condensate systems shall be of the centrifugal type selected based on criteria in ASHRAE handbooks. Materials, types of seals, bearings, wear rings, shafts and other features shall be selected based on specific system requirements and economic evaluation. The design professional shall consider the use of primary-secondary type pumping systems and high-efficiency motors for pumps for all hot and chilled water distribution systems.

On systems where system pumping horsepower requirements are greater than 20 bhp, the design professional shall consider the use of variable speed drives or parallel pumping arrangement.

Standby pumps shall be provided for all systems as dictated by project-specific criteria. Pumps shall comply with HI standards.

1550-2.3.3 Piping, Fittings and Accessories

Piping size shall comply with Section 1550-23.1, General. Selection of materials, installation of piping, fittings, valves, and accessories, as well as methods of joining and suspending piping systems, shall be based on pressure requirements, pipe size, and type of service as recommended by ASHRAE Equipment handbook and ASME B16 series, ASTM G46 and ASME B31.1. The design professional shall calculate and design for expansion of piping systems. Chilled water, heating water, and condenser water piping shall be Schedule 40 piping with flanged, screwed, grooved-end or welded fittings depending on pipe sizes and operating conditions. Boiler feed water and condensate piping shall be schedule 80 black steel with appropriate fittings depending on pipe sizes.

1550-2.4 Steam Distribution Systems

All steam piping shall comply with ASME B31.1 and be a minimum of Schedule 40 black steel. Fittings, valves, and accessories shall be selected based on pipe size and temperature and pressure conditions.

1550-2.5 Air Handling and Air Distribution Systems

1550-2.5.1 General

The design professional shall consider and design air handling equipment and air distribution systems sized to optimize both initial cost and air handling system operating and maintenance costs according to the procedures outlined here and in Section 0110-12.7, Building Analysis Procedures.

The design professional shall provide all air handling system equipment (fans, terminal units, air handling units, etc.) with vibration isolators and flexible ductwork connectors to minimize transmission of vibration and noise. Systems shall satisfy the NC levels recommended for various types of spaces and vibration criteria as listed in the ASHRAE handbooks. Where air handling equipment and air distribution systems cannot meet these requirements, sound attenuation devices shall be installed in the air handling systems.

Air flow diagrams shall be developed and provided in the preliminary design phase unless waived by the DOE project criteria. These diagrams shall be provided for each air handling and air distribution system, and shall include capacities and locations of fans, coils, filters, terminal devices, and other major air distribution system equipment, as well as air flows and system air pressures and space pressure differentials.

Airflow velocities shall be designed to minimize settling of entrained particles as outlined in the ACGIH Industrial Ventilation Manual.

Air handling and air distribution systems shall meet the energy conservation requirements for transport energy in ASHRAE Standard 90. Controls for air handling and air distribution equipment shall comply with Section 1595-6, Control of Air Handling Systems. Supply and outdoor air intakes shall be located a minimum of 10 feet from any exhaust opening.

1550-2.5.2 Air Handling Units

The design professional shall select packaged air handling units complete with filters, coils, mixing boxes, fan section, and other accessories or built-up air. handling units based on an LCC evaluation and the requirements of NFPA 90A, AMCA Publication 99, AMCA Publication 261, and ARI 430.

1550.2.5.3 Fans/Motors

Fans shall be designed and specified to assure stable, nonpulsing aerodynamic operation in the range of operation over varying speeds. Air handling units and fans in sizes over 1 hp shall use belt drives. Fans with motors of 10 hp or less shall be designed with adjustable motor pulley sheaves to assist in air balancing of systems. Fans with motors greater than 10 hp shall use fixed (non-adjustable) drives that can be adjusted by substituting fixed motor pulley sheaves of different diameters. Supply air handling units and return air fans in variable-air-volume systems shall control capacity through the use of variable-speed drives, inlet vanes or scroll bypass dampers. All fans shall comply with AMCA Standard 210, ASHRAE Standard 51, and ASHRAE Equipment handbook.

Fans shall be located within the ductwork system according to the requirements of AMCA Publication 201 and ACGIH Industrial Ventilation Manual. The design professional shall consider the use of variable-speed drives on fans in variable-air-volume systems where the supply fans are larger than 5 BHP. Motors shall be sized according to properly calculated BHP fan requirements and shall not use oversized fans and motors to meet future capacity needs unless so directed by DOE project criteria.

The design professional shall consider the selection of fan construction materials based on corrosion resistance and cost. Spark-resistant construction shall be used where required by NFPA.

All fans and accessories shall be designed and specified to meet all smoke and flame spread requirements of NFPA 255.

1550-2.5.4 Coils

Heating and cooling coils shall comply with ARI 410. Heating or cooling coil selection shall not conflict with ASHRAE Fundamentals handbook or ASHRAE Equipment handbook. The design professional shall specify that coil manufacturers certify coil performance by ARI certification or provide written certification from a nationally recognized independent testing firm that will verify coil performance to be in accordance with ARI 410.

Heating and cooling coils shall be specified of materials appropriate for corrosive atmosphere in which they are contained.

Cooling coils shall be designed with a maximum face velocity of 600 fpm. Coils designed with face velocities exceeding 500 fpm shall be specified with provisions to prevent condensate carryover, or use moisture eliminators. Coils shall be specified with drain feature.

Recirculating air systems with outside air winter design temperatures below freezing shall be designed with a preheat coil located either in the outside air intake or in the mixed air stream upstream of the cooling coil, unless the theoretical mixed air temperature is calculated to be above 35°F. In this ease, the preheat coils may be omitted if adequate baffling is provided to guarantee positive mixing of the return and outdoor air. Preheating coils shall be specified and designed to maintain discharge air temperature without modulation of the steam or hot water flow through use of modulating face and bypass dampers. Steam modulation may be used for control of steam coils in moderate climates where proven to be reliable without concern of coil freeze-up.

1550-2.5.5 Air Cleaning Devices

General

Air cleaning equipment for ductwork installation shall be easily removable, servicable, and maintainable. Air cleaning equipment shall have face velocities as recommended by the filter manufacturer and the design manuals recommended above to achieve maximum efficiency and minimum pressure drop.

Filters shall be constructed of noncombustible materials meeting the requirements for UL 900, Class L Air filters shall be located on the suction side of fans and coils and in other special locations as required for air treatment. Air-filter pressure drop gauges of the diaphragm-actuated, dial-type (preferred) or the inclined manometer type shall be located on all filter assemblies.

High-Efficiency Particulate Air Filters

HEPA filter assemblies shall comply with ASME N509.

HEPA filtration systems shall be used to minimize the release of particulate contaminants such as carcinogens, infectious agents, radioisotopes, or highly toxic materials when determined by safety analysis to be necessary.

The design professional shall design for a location that facilitates in-place testing of HEPA filters, with particular attention given to plenum hardware provisions that allow for testing of the HEPA filter bank without requiring the testing personnel to enter the plenum. Utility services shall be extended to the plenum location (e.g., electrical receptacles and compressed air) to facilitate testing work. In-place testing design requirements shall meet all the recommendations of UL 586, ASME N510, and ERDA 76-21. HEPA filtration systems shall be designed with prefilters installed upstream of HEPA filters to extend the HEPA filter's life. The design professional may eliminate the installation of pre-filters if an analysis of filtration requirements and consideration of the filter assembly justifies omission.

Filters for Air Handling Systems Serving Inhabited Spaces

Filters include air filter devices and air filter media used in building environmental air handling systems for removing particulate matter from atmospheric air. These filters shall be specified to meet minimum efficiencies required by the ASHRAE Dust Spot method using atmospheric dust for medium-efficiency applications. Filters shall be specified and installed for use as pre-filters, medium-efficiency filters, or high-efficiency filters. These filters shall comply with ARI 850.

High-efficiency filters and assemblies shall comply with DOE project criteria. Electronic air cleaners and extended dry-surface filters shall be considered for use as high-efficiency filters. Pre-filters are normally provided, being either pre-filter or medium-efficiency filters depending on the upstream air particle size distribution.

Air-Cleaning Devices for Special Applications

Filters include dry type dust collectors, wet collectors, centrifugal collectors, adsorbers, absorbers, oxidizers, and chemical treatment filters that are used primarily in industrial and process-type applications associated with air or gases that have heavy dust loadings in exhaust systems or stack gas effluents. Filters shall be designed according to the requirements given in DOE project criteria, ASHRAE Equipment handbook, and ACGIH Industrial Ventilation Manual. Adsorbers for nuclear or toxic applications should comply with ERDA 76-21, ASME N509, and ASME N51O.

Fire Protection of HEPA Filter Assemblies

In providing fire protection for the HEPA filters, the design shall separate prefilters or fire screens equipped with water spray sufficiently from the HEPA filters to restrict impingement of moisture on the HEPA filters. Under conditions of limited separation, moisture eliminators or other means of reducing entrained moisture shall be provided. Moisture eliminators may be omitted where system design provides sufficient filter redundancy to ensure continued effluent filtration in the event of fire within any portion of the system. The HEPA filter fire protection system shall be activated in a manner consistent with the fire protection system in the room or building in which the filters are located and as directed by the cognizant DOE fire protection authority.

1550-2.5.6 Ductwork Systems

Ductwork systems shall be designed for efficient distribution of air to and from the conditioned spaces with consideration of noise, available space, maintenance, air quality and quantity, and an optimum balance between expenditure of fan energy (annual operating cost) and duct size (initial investment).

Ductwork systems shall be designed to meet the leakage rate requirements of SMACNA HVAC Air Duct Leakage Test Manual.

Ductwork accessories, and support systems shall be designed to comply with the following:

- ASHRAE Fundamentals handbook
- SMACNA HVAC Duct Construction Standards-Metal and Flexible
- SMACNA Fibrous Glass Duct Construction Standards
- SMACNA Round Industrial Duct Construction Standards
- SMACNA HVAC Duct Design Manual
- ACGIH Industrial Ventilation Manual
- NFPA 45
- ERDA 76-21

Ductwork shall also be designed to comply with NFPA 90A, including specification and installation of smoke and fire dampers at fire wall penetrations and smoke pressurization/ containment dampers as required for smoke pressurization/evacuation systems. Fire dampers shall not be used on exhaust system ducting if it is required to maintain confinement of hazardous materials during and after a fire event.

Exhaust ductwork shall comply with NFPA 91. Ductwork for kitchen exhaust systems shall comply with NFPA 96.

Ductwork shall be designed to resist corrosive contaminants if present. Ductwork that handles air exhausted from shower rooms, dishwashing areas, or other areas causing condensation on the duct interior shall be of aluminum construction, have welded joints and seams, and have drainage at low points.

Ductwork thermal insulation shall comply with ASHRAE Standard 90. Ductwork shall be acoustically insulated to meet acceptable noise criteria.

Ductwork systems shall have testing and balancing dampers and accessories specified and installed as discussed in Section 1550-3.2, Testing and Balancing Devices. The design professional shall specify automatic controls for ductwork systems and provide them in required locations as discussed in Section 1595, Control of Air Handling Systems.

Penetrations of ductwork through security barriers shall be minimized. Such penetrations more than 96 square inches in area and more than 6 inches in minimum dimension shall provide a penetration delay equal to that required for the security barrier. The physical attributes and intended service of the ductwork and the axial configuration of the barrier penetration shall be considered when considering that penetration delay.

Table 1550-3.2a Required Balancing Devices for Air Distribution Systems

System Components	Required System Devices
Diffusers, grilles, registers	Round butterfly or square/rectangular opposed blade volume damper, either integral with device or in spin-in take offs
Branch ductwork runs	Rectangular/square or round (with more than one opposed blade damper and terminal device). Sealed test hole for pitot tube traverse
Fan discharge ductwork	Sealed test holes for pitot tube traverse. Sealed test hole for static pressure measurements
Fan suction ductwork	Sealed test hole for static pressure measurement
Cooling coil suction and discharge airstreams	Duct-mounted airstream thermometer
Heating coil suction and discharge airstreams	Duct-mounted airstream thermometer
Mixed air plenum airstream	Duct-mounted airstream thermometer

1550-3 TESTING, ADJUSTING AND BALANCING

1550-3.1 System Performance Tests

The design professional shall specify system performance tests for mechanical air distribution and HVAC water distribution systems to verify compliance with DOE project criteria. These tests shall be performed by an independent AABC testing organization in accordance with the guidelines contained in ASHRAE Systems handbook and AABC Volume A-82 or by others as dictated in project-specific criteria.

1550-3.2 Testing and Balancing Devices

HVAC air and water distribution systems shall be provided with permanently installed calibrated testing and balancing devices and access as needed to accurately measure and adjust water flows or air flows, pressures, or temperatures as required. The design professional shall provide as a minimum the balancing devices in Table 1550-3.2a and Table 1550-3.2b. Test devices shall be located and installed according to AABC Volume A-82.

1550-3.3 General Guidelines

Test and measuring locations shall be noted on construction drawings. The use of duct mounted air flow monitoring stations shall be considered where limited duct space or configuration restrict the use of pitot tube traverse procedures or where especially sensitive measuring requirements are dictated by the DOE project criteria.

1550-99 SPECIAL FACILITIES

1550-99.0 Nonreactor Nuclear Facilities-General

1550-99.0.1 General Ventilation and Off-Gas Criteria

These criteria cover ventilation and off-gas systems, or portions of them, that are classified as safety class items in accordance with Section 1300-3.2, Safety Class Items. Safety class ventilation and off-gas systems are generally designed to operate in conjunction with physical barriers to form a confinement system to limit the release of radioactive or other hazardous material to the environment and to prevent or minimize the spread of contamination within the facility.

Ventilation and air-conditioning systems designed to provide a comfortable working environment and whose functions are not necessary to provide confinement are generally not designed as safety class systems.

Ventilation systems shall be designed to provide a continuous airflow pattern from the environment into the building and then from noncontaminated areas of the building to potentially contaminated areas and then to normally contaminated areas. Thus, the airflow is toward areas of higher radioactive or hazardous material contamination, Dampers shall be located so that cross-contamination will not occur in case of a localized release of material.

Electronic air cleaners shall not be used in systems recirculating air.

Table 1550-3.2b Required Balancing Devices for Water and Steam Distribution Systems

System Components (Water)	Required System Devices
Pump suction and discharge piping	Manifold pressure gauge with pressure taps
Pump discharge piping	Flow measuring device (type depending on accuracy required)
Chiller evaporator water suction and discharge piping	Thermometer/test well and pressure gauge and gaugecock
Chiller condenser water suction and discharge piping	Same devices as required for chiller evaporator piping
Boiler or heat exchanger suction and discharge piping	Same devices as required for chiller evaporator piping. Note: Simple, easy-to-install, state-of-the-art equipment such as magnetic vanes should also reconsidered.
Heating or cooling coil (AHU) suction and discharge piping	Thermometer/test well; pressure gauge/pressure tap
Heating or cooling coil (AHU) discharge piping	Presentable calibrated balancing valve with integral pressure test ports
Reheat coil, fan coil unit, unit heater, ports and finned tube radiation, convector: 1) discharge piping 2) suction piping	1) Presentable calibrated balancing valve with integral pressure test ports 2) temperature test 3) pressure tap
Three-way control valves (each port) suction and discharge piping	Pressure tap

System Component (Steam)	Required System Devices
Boiler discharge piping	Flow measuring device (orifice or venturi type)

Ventilation system balancing shall be specified to ensure that the building air pressure is always negative with respect to the outside atmosphere.

Portions of ventilation and off-gas systems that provide required functions following a seismic event shall be designed to be functional following a DBE.

The use of downdraft ventilation within occupied process areas shall be considered as a means to reduce the potential inhalation of contamination.

The failure of ventilation and off-gas systems not designed as safety class systems shall not prevent other facility safety class systems from performing their required safety functions.

Hydrogen gas storage areas and process areas that use hydrogen shall have provisions for sufficient ventilation to ensure that under all conditions (normal operations, anticipated operational occurrences, and DBA conditions), the hydrogen concentration in the air and/or off-gas will never exceed 4 percent by volume.

Gas storage areas and process areas that use hazardous materials shall have ventilation systems designed to ensure that the hazardous material concentrations do not exceed the limits referenced in DOE 5480.10 and are ALARA in the workplace environment. Effective loss-of-ventilation alarms shall be provided in all of these areas.

Suitable off-gas stream pretreatment shall be provided upstream of the off-gas cleanup system to remove or reduce the concentration of chemicals that would adversely affect system operation.

Components of ventilation and off-gas systems that require electric power to perform their safety functions shall be considered safety class loads.

Adequate instrumentation and controls shall be provided to assess ventilation or off-gas system performance and allow the necessary control of system operation.

Equipment in ventilation and off-gas systems shall be appropriately qualified to ensure reliable operation during normal operating conditions, anticipated operational occurrences, and during and following a DBE.

1550-99.0.2 Confinement Ventilation Systems

The design of a confinement ventilation system shall ensure the ability to maintain desired airflow characteristics when personnel access doors or hatches are open. When necessary, air locks or enclosed vestibules shall be used to minimize the impact of this on the ventilation system and to prevent the spread of airborne contamination within the facility. The ventilation system design shall provide the required confinement capability under all credible circumstances with the addition of a single failure in the system.

If the maintenance of a controlled continuous confinement airflow is required, electrical equipment and components required to provide this airflow shall be supplied with safety class electric power and provided with an emergency power source.

Air cleanup systems shall be provided in confinement ventilation exhaust systems to limit the release of radioactive or other hazardous material to the environment and to minimize the spread of contamination within the facility as determined by the safety analysis. The following general cleanup system requirements shall be met, as appropriate, for ventilation system design:

- The level of radioactive material in confinement exhaust systems shall be continuously monitored. Alarms shall be provided that will annunciate in the event that activity levels above specified limits are detected in the exhaust stream. Appropriate manual or automatic protective features that prevent an uncontrolled release of radioactive material to the environment or workplace shall be provided.

- To limit onsite doses and to reduce offsite doses by enhancing atmospheric dispersion, elevated confinement exhaust discharge locations are required. The height of the exhaust discharge location shall ensure that the calculated consequences of normal or accidental releases shall not exceed the radiological guidance contained in Section 1300-1.4, Guidance on Limiting Exposure of the Public. In addition, to the extent practical, all normal and accidental releases shall be maintained at ALARA levels.

- An elevated stack shall be used for confinement exhaust discharge. Provisions shall be made to ensure an adequate ventilation exhaust discharge path in the event of stack failure. The stack shall be located so that it can not fall on the facility or an adjacent facility containing safety class items. The alternative is the construction of a stack that shall remain functional following a DBE, severe natural phenomena, and man-made events. Stack location and height shall also consider intakes on the facility and adjacent facilities to preclude uptake.

- Safety class air filtration units shall be designed to remain functional throughout DBAs and to retain collected radioactive material after the accident.

- Air sampling locations shall meet ACGIH/ASHRAE criteria. Sample collecting devices shall be located as close to the sampling probe as possible.

- The number of air filtration stages required for any area of a facility shall be determined by safety analysis based on the quantity and type of radioactive materials to be confined.

- Air filtration units shall be installed as dose as practical to the source of contaminants to minimize the contamination of ventilation system ductwork.

- Ducts shall be sized for the transport velocities needed to convey, without settling, all particulate contaminants.

- Air filtration units shall be located and provided with appropriate radiation shielding to maintain occupational doses ALARA during operations and maintenance.

- Air filtration units shall be designed for ease of recovery of fissile material and other materials capable of sustaining a chain reaction in case of an accident as well as during normal operations.

- The cleanup system shall have installed test and measuring devices and shall facilitate monitoring operations, maintenance, and periodic inspection and testing during equipment operation or shutdown, as appropriate.

- Where spaces, such as a control room, are to be occupied during abnormal events, safety class filtration systems shall be provided on the air inlets to protect the occupants. As a minimum, air inlets shall be filtered to limit the loading of exhaust filters with normal atmospheric dust.

- Either HEPA filtration or fail-safe backflow prevention for process area intake ventilation systems shall be provided.

- Consideration shall be given to providing roughing filters or prefilters upstream of a HEPA filter to maximize the useful life of the HEPA filter and reduce radioactive waste volume.

Hot cell exhaust systems shall be as follows:

- Exhaust prefilters and HEPA filters shall be installed in such a manner as to facilitate filter changing and repairs.

- Standby filters provide backup protection and facilitate changing the primary filters without shutting down the exhaust fans. Standby filters shall be installed outside the cell and sealed in an acceptable enclosure for direct maintenance.

- All exhaust systems shall have monitors that provide an alarm if the concentration of the hazardous material in the exhaust exceeds specified limits.

In facilities where plutonium or enriched uranium is processed, the following additional requirements shall be met:

- Wherever possible, the designer shall provide enclosures for confining the process work on plutonium and enriched uranium. Design criteria for enclosures of radioactive and other hazardous materials are provided in Section 1161, Enclosures. When these confinement enclosures are specified and designed, consideration shall be given to whether room ventilation air can be recirculated. If a recirculation ventilation system is provided, the design shall provide a suitable means for switching from the recirculation mode to a once-through ventilation system.

- A safety analysis under DOE direction shall establish the minimum acceptable performance requirements for the ventilation system and the response requirements of system components, instrumentation, and controls under normal operations, anticipated operational occurrences, and DBA conditions.

  The safety analysis shall determine system requirements such as the need for redundant components, emergency power for fans, dampers, special filters, and fail-safe valve/damper positions. The safety analysis and the guidelines provided by the cognizant DOE authority shall determine the type of exhaust filtration required for any area of the facility during normal operations, anticipated operational occurrences, and DBA conditions.

- If advantageous to operations, maintenance, or emergency personnel, the ventilation system shall have provisions for independent shutdown. Shutdown of a ventilation system under such conditions shall be considered in light of the effects on air flows in other interfacing ventilation systems. When a system is shut down, positive means of controlling backflow of air to noncontaminated spaces shall be provided by positive shutoff dampers, blind flanges, or other devices.

- Equipment to continuously monitor oxygen levels shall be provided for occupied working areas of facilities equipped with significant quantities of inerted or oxygen-deficient process glovebox lines.

- The supply air to enclosures that confine the processing of plutonium and enriched uranium shall be filtered by HEPA filters at the ventilation inlets to the enclosures and area confinement barriers to prevent the transport of radioactive contamination in the event of a flow reversal.

- If room air is recirculated, at least one stage of HEPA filtration shall be provided in the recirculation circuit. The design shall include redundant filter banks and fans that shall be located based on the results of the safety analysis. If recirculation systems are used, a means shall be provided to prevent contaminated process enclosure air from exhausting into the working area rooms. Process enclosure air (from hoods, gloveboxes, etc.) shall be treated and exhausted without any potential for recirculation to occupied areas.

- Ventilation system components and controls that require electric power to perform safety functions shall be supplied with a safety class UPS and/or emergency power supply as is determined to be required by a systems design/safety analysis.

- The designer shall specify and locate components in the exhaust systems to remove radioactive materials and noxious chemicals before the air is discharged to the environment. These components shall be capable of safely handling products of combustion. These systems shall be designed to operate under DBA conditions including the DBF. The exhaust system design shall ensure that effluents are safely directed through the appropriate ventilation ducts and not spread beyond the physical boundary of the ventilation system until treated.

- The number of required exhaust filtration stages to limit the quantity and concentration of airborne radioactive or other hazardous materials released to the environment from any area of the facility shall be determined by the safety analysis. The design shall include all necessary cleaning and detection equipment for detection and removal of noxious chemicals from the exhaust ventilation system.

- HEPA filters shall be installed at the interface between the enclosures that confine the process and the exhaust ventilation system to minimize the contamination of exhaust ductwork. Prefilters shall be installed ahead of HEPA filters to reduce HEPA filter loading. The filtration system shall be designed to allow reliable in-place testing of the HEPA filter and simplify filter replacement.

- Separate exhaust ventilation system ductwork and the initial two stages of filtration shall be designed for exhaust air from enclosures that confine the process (e.g., gloveboxes). These systems shall maintain a negative pressure inside the enclosure with respect to the operating area. These systems shall be designed to remove moisture, heat, and explosive and corrosive gases, as well as other contaminants. These systems shall be designed to automatically ensure adequate inflow of air through a credible breach in the enclosure confinement.

- Enclosures that confine the process and are supplied with gases at positive pressure shall have positive-acting pressure-relief valves that relieve to the exhaust system to prevent over-pressurization of the process confinement system.

- The design of air cleaning systems for normal operations, anticipated operational occurrences, and DBA conditions shall include the use of the following equipment as directed by the cognizant DOE authority and these criteria:

  - Prefilters
  - Scrubbers
  - Process vessel vent systems-HEPA filters
  - Sand filters
  - Glass filters
  - Radioiodine adsorbers
  - Demisters
  - Condensers
  - Distribution baffles
  - Pressure and flow measurement devices

- Airborne contaminant cleaning systems shall be designed for convenient maintenance and the ability to decontaminate components and replace components in the supply, exhaust, and cleanup systems without exposure of maintenance or service personnel to hazardous materials. Filtration systems shall be designed so that a bank of filters can be completely isolated from the ventilation systems during filter element replacement.

1550-99.0.3 Off-Gas Systems

The sources and characteristics of radioactive material in off-gas systems shall be identified. The design of an off-gas system shall be commensurate with the characteristics of the radioactive material in the off-gas and the risk associated with its release as an effluent.

The design of the off-gas system shall ensure that off-site doses resulting from normal system operation are maintained within the guidelines referenced in Section 1300-1.4.3, Routine Releases, and are ALARA.

Portions of off-gas systems and components that are required to control or limit the release of radioactive material to the environment or for safe operation of the system shall be provided with redundancy.

Electrical equipment and components of off-gas systems that require electric power to perform their safety functions shall be considered safety class loads.

Adequate instrumentation shall be provided to monitor and assess system performance and to provide necessary alarms. Appropriate manual or automatic protective features shall be provided to prevent an uncontrolled release of radioactive material to the environment and to minimize the spread of contamination within the facility.

The off-gas system shall be designed to allow periodic maintenance, inspection, and testing of components.

The system's capacity shall be consistent with the needs for handling off-gas from components and systems during normal operations, anticipated operational occurrences, and DBA conditions. Process system tanks and other sealed components shall be vented to an off-gas system.

The design of process confinement off-gas treatment systems shall preclude the accumulation of potentially flammable quantities of hydrogen generated by radiolysis or chemical reactions within process equipment.

Vents from liquid components shall be provided with traps and drains to prevent inadvertent flooding of off-gas systems.

Adequate shielding shall be provided for filters, absorbers, scrubbers, and other off-gas treatment system components to maintain occupational exposures within the limits specified in DOE 5480.11. In addition, to the extent practical, the shielding design shall use ALARA principles to minimize overall exposures.

Corrosive gases and particles from vats, scrubbers, and similar equipment in gloveboxes shall be neutralized prior to reaching the HEPA off-gas filters.

Air ventilated gloveboxes shall have the ability to safely contain in-box contaminants when an access port is opened or a glove ruptures.

Vent streams containing UF_6 shall be equipped with chemical traps to remove radionuclides from the gases before they are vented to the atmosphere. The following are typical vents to be equipped with traps:

- Purge cascade
- Cold recovery
- Buffer seal exhaust stations
- Wet-air evaluation stations

Traps shall be designed for nuclear criticality safety under conditions of design loading of fissile or other materials capable of sustaining a chain reaction. The design shall also minimize the spread of contamination during replacement.

All vent streams having the potential of containing significant quantities of radioactive material shall be processed by an off-gas cleanup system before being exhausted to the environment. The cleanup systems shall be designed to remove particulate and noxious chemicals and control the release of gaseous radionuclides.

1550-99.4 Explosive Facilities

1550-99.4.1 Ventilation Requirements

The ventilation requirements for an explosives facility shall be determined by the safety analysis for the proposed facility.

Exhaust ventilation shall be used to control explosives dust (or other hazardous materials used in or resulting from explosives operations) that may create a hazard to operating personnel or contaminate the operating area. When exhaust ventilation is used to remove explosives dust, an approved dust collection system is required to prevent the release of dust outside the building.

Exhaust ventilation and collection systems for control of explosives dust and materials associated with explosives production shall be designed to meet minimum requirements established in these criteria and ACGIH Ventilation Manual. The exhaust ventilation system shall have sufficient capture and adequate makeup air to reduce exposure to explosives dusts, or materials used in conjunction with explosives, to ALARA. This is particularity important when toxicity information and occupational exposure limits are not available for the explosives in use.

The ventilation system shall be constructed of materials that are compatible with explosives work. The ducting system shall be designed to allow for inspection and disassembly without encouraging collection of explosives material in the system. The need for filtration shall be considered to ensure that release of contamination is minimized.

The following radiological criteria shall be incorporated into the design of ventilation systems where both explosives and radiological hazards are relevant. For the DBA, the ventilation system in the affected area shall be designed to ensure that the radiological requirements of Section 1300-1.4.2, Accidental Releases, are satisfied. To minimize the dispersal of contamination from accidents less severe than an explosion, supply and exhaust air shall be filtered to ensure that airborne releases to the environment do not exceed the concentration guides specified in the directive on Radiation Protection of the Public and the Environment in the DOE 5400 series. Air supply flows shall be directed toward the areas of the highest potential concentration.

1550-99.4.2 Collection of Explosives Wastes

Provision shall be made for the removal of explosives waste from any area in which explosives waste is generated. Removal of explosives waste may be accomplished by collecting dust/fines in a wet or dry vacuum system; collecting dust, fines, or chips in a slurry of water or nonflammable solvent; or by collecting solid waste in receptacles.

Explosives waste shall be collected and maintained separately from conventional waste.

Mixing of incompatible explosives shall be avoided. Receptacles shall be clearly labeled to indicate the type of permissible waste.

Vacuum Collection of Explosives Dusts

When using a wet system, the design of that system shall provide for the following:

- The dust shall be maintained in a wet form and in close proximity to its point of origin.
- The dust shall be maintained in a wet form until removed for disposal.
- Water-soluble explosives shall not be collected in a wet system.

Storage compatibility Group A explosives (for definition see DOE/EV 06194) may be collected by a vacuum system provided they are maintained in a wet form using a wetting agent that is kept close to the point of intake. Use of a vacuum system for collecting these more sensitive materials shall be confined to operations involving small quantities of explosives.

Dry-type dust collection chambers, except portable units, should be located in the open and outside operating buildings, or in buildings exclusively set aside for that purpose. The quantity of explosives collected shall not exceed the capacity of the shielding to protect operating personnel. This limit shall be determined by the degree of barricading and the appropriate intraline distance.

If dry dust collection outside the building is not practical, a separate room within the building shall be designated for the purpose. This room shall not contain other operations, nor shall it be used as a communicating corridor or passageway between other operating locations within the building when explosives are being collected.

Stationary and portable wet-type collectors may be placed in the explosives operating bays or cubicles if the quantity of explosives in the collectors does not exceed 2 kg. If placed in separate cubicles, the explosives weight limits may be increased by an amount determined by the capabilities of the cubicle walls to serve as operational shields.

Collection systems and chambers shall be designed to prevent pinching explosives between metal parts.

There shall be no screw threads, recesses, or cracks that may be exposed to explosives contamination in a dust collection system. Dust collection lines should be equipped with flanged connectors and inspection ports. Pipes or ducts through which explosives are conveyed shall have long radius bends with a Centerline radius of at least four times the diameter of the pipe or duct.

Dust collectors shall be designed in such a manner that explosives dust is prevented from reaching any mechanical power source of the collection system. Two collection chambers shall be installed in series ahead of the pump or exhauster to prevent explosives dust from entering the vacuum producer in dry vacuum collection systems. In addition, non-sparking fans and dust-tight motors shall be used.

The entire explosives-dust collecting system shall be electrically bonded and grounded with resistance-to-ground not exceeding 10 ohms. The grounds shall be tested periodically.

1550-99.4.3 Air Monitoring Requirements for Explosives/Plutonium Bays

Where explosives and plutonium are present in the same bay, continuous air monitoring systems shall be provided in work locations for airborne contamination detection. The systems shall be equipped with audible and visual alarms at both the immediate work location and a location external to the immediate area. The systems shall be sensitive to radionuclides associated with the operation and shall sample air representative of the air breathed by the worker for whom the monitoring is provided.

1550-99.8 Telecommunications, Alarm, and ADP Centers and Radio Repeater Stations

1550-99.8.1 General

These criteria shall apply to telephone switching centers, teletype, data, and facsimile centers, computer or ADP centers, radio control centers, security alarm control centers, and radio repeater stations.

Heat recovery options for utilization of the heat produced by equipment such as rectifier-charger bays, radio and microwave transmitters, and ADP equipment to conserve energy in the heating season shall be considered on the basis of LCC as described in 0110-12.7.1. The ventilation design shall also consider directly exhausting heat gains from this equipment during the cooling season to minimize air-conditioning requirements.

1550-99.8.2 Air-Conditioning and Ventilating Systems

Air-conditioning systems for telecommunications, alarm, and automatic data processing centers shall comply with NFPA 90A and shall be completely separate and independent from other air distribution systems. Initial equipment heat loads for telecommunications and computer rooms shall be increased by 25 percent or to satisfy a five-year growth forecast (whichever is greater) in sizing the systems. Noncombustible duct construction materials shall be specified. Air ducts serving other spaces shall be designed to bypass these areas or shall be encased in a fire resistant enclosure with suitable fire doors and dampers as required by NFPA 90A.

Operating and equipment areas that contain dust-sensitive equipment shall be designed with a ventilation system that will maintain positive pressures and is provided with HEPA filtration systems.

Telephone Switching Centers

Where switchboard or console operators are seated higher than other employees within the room, the air-conditioning system shall be designed to minimize temperature imbalances between the working levels for employee comfort.

Power control boards, rectifiers, storage batteries, battery chargers, ringing machines and tone generators shall be located in rooms separate from the switching equipment and shall be provided with separate exhaust systems. Power equipment room ventilation systems shall be designed to maintain a positive air pressure in the equipment area.

Storage Battery Areas

Storage battery areas shall be ventilated according to the NEC, Section 4808(a) and ASHRAE handbooks. Where storage batteries are to be located in the same room with telecommunications or alarm equipment, in lieu of providing a separate (and separately ventilated) battery room, the design professional shall consider the adequacy of the normal room ventilation system and the need for supplemental or emergency backup ventilation during scheduled or emergency shutdown of the central ventilation system.

Security Alarm Control Centers

HVAC systems shall be designed with air filtration features to protect against infiltration of aerosol and gas incapacitating agents.

Radio Repeater Stations

HVAC systems shall be designed to use heat gains from equipment for maintaining the operating room ambient temperature at not less than 40°F during the heating season. Auxiliary heaters shall be provided with adequate capacity to maintain an inside temperature of at least 70°F in the operating room at design outdoor winter conditions assuming a power outage to the radio equipment. Auxiliary heaters shall maintain temperature in the emergency engine-generator room at not less than 40°F.

Exhaust fans shall provide sufficient ventilation during the cooling season to maintain the internal station temperatures required for equipment operation. The primary ventilating air system shall be designed with a backup system. Air-conditioning and dehumidification equipment shall be designed to meet environmental control requirements if an exhaust system cannot do so.

Air intakes equipped with replaceable glass-fiber type filters shall be located to provide makeup air for the heat exhaust system. A separate exhaust or air-conditioning system shall be provided for the engine-generator room to provide cooling in accordance with the manufacturer's recommendations.

1550-99.10 <u>Secure Conference Rooms</u>

Based on the project-specific criteria, either an independent heating-cooling system with minimal utility service penetration through the room envelope shall be specified and designed or special sound attenuation devices shall be provided in the central heating-cooling system around the conference room.

These systems should reduce airborne or structure-borne sound transmission paths. Suitable sound traps, metal air duct isolation material on the secure side, packing around pipe penetrations and fixed pipe flanges on both sides of the penetrations, personnel access barriers/controls for exterior ductwork or other security devices shall be specified and designed as required and directed in the DOE project criteria.

See also Section 0110-99.10, Secure Conference Rooms

1555 CENTRAL PLANT HEAT GENERATION/DISTRIBUTION

1555-1 PLANNING

1555-1.1 General

These criteria shall be applied in the planning and design of steam and HTW generation and distribution systems and cogeneration facilities.

DOE/MA 0129 shall be used as a general reference.

1555-1.2 Facility Sizing

New facilities shall be sized to accommodate all present energy needs as well as all confirmed future needs within two years. Consideration shall be given to a plant design that can be easily expanded should potential future loads in addition to confirmed short-term loads become a reality. Load computations to establish boiler capacity shall be based on the building design heating load as developed in conformance with ASHRAE Fundamentals handbook, Chapter 25. To this shall be added process heating loads (if any) and an allowance for piping losses where heat loss through piping does not transfer to the heated space. For process plants, the process heat losses shall be investigated during the design stage to determine if heat can be recovered, thereby reducing the boiler load.

A load analysis should be performed, including determination of the peak, average, and baseload demand. The load factor, which is the ratio of peak demand to average demand, should be maintained as close to unity as practical.

The amount of installed excess boiler capacity shall be considered on a case-by-case basis depending on the effect of loss of a boiler. For heating and process loads of a critical nature for vital programs such as weapons production and uranium enrichment, the applicable DOE program agency shall determine whether 100-percent redundant heat generation capacity is required.

For routine office heating applications, no redundant capacity is allowed.

Modular boiler installations shall be considered for all applications to maintain a high operating plant efficiency throughout the year. Number and size of the boilers shall be based on the number of operable hours at full and part load operation, turn-down ratio of the boiler being considered, efficiency at part load, and year round process or summer loads. Use of a baseload boiler shall be considered when a year-round process demand exists. The system shall be designed to satisfy peak demand by operating over its maximum rating for short periods of time.

The possibility of operating small local boilers rather than the central plant to satisfy summer loads shall also be considered as well as the possibility of using excess summer capacity for satisfying air-conditioning requirements using absorption chillers.

Sufficient capacity shall be furnished to allow one boiler to be down for inspection, maintenance, or on standby, while the remaining boiler(s) maintain normal operations.

1555-1.3 Generating Facility Location

The generating facilities shall be located to allow efficient steam/hot water distribution throughout the site and allow for future expansion of the generating and distribution system. The facility shall also be located to minimize problems associated with the following:

- Noise
- Dirt
- Air pollution
- Harmful effects to adjacent property owners
- Accommodate fuel deliveries and storage
- To take advantage of prevailing winds

1555-1.4 Central Facilities Versus Satellite Facilities

The installation of one or more satellite boiler facilities rather than a single central boiler complex shall be evaluated by LCC analysis when one or more of the following conditions exist:

- Art extensive distribution system connecting several separate steam users is required
- Requirements exist for several different steam pressures
- Variable steam loadings exist with respect to time or quantity

Alternate energy supply distribution systems such as natural gas, steam, and condensate return systems shall be included in the analysis. Consideration shall be given to convertibility to noncritical fuels in accordance with DOE 4330.2C.

1555-1.5 Selection of Fuels

Selection of fuels shall comply with DOE 4330.2C. Fuel-burning installations with input of 100 million BTU per hour or greater shall comply with FUA.

1555-1.6 Cogeneration

The use of a cogeneration plant as a possible alternative shall be considered in the planning of any large steam generation facility. The feasibility of cogeneration with HTW or HTW boilers or HTW to steam generators shall be considered.

In determining the feasibility of cogeneration, the following factors shall be considered:

- Energy demand and cost, peak load, average load, seasonal variations, and utility rate structures

- Regulatory concerns: PURPA, relevant environmental regulations, and current local regulations

Generation plants shall be sized to accommodate existing loads.

1555-2 STEAM AND HIGH-TEMPERATURE WATER GENERATION

1555-2.1 General

All boilers shall comply with the ASME Boiler and Pressure Vessel Code.

The recommendations of FCC Technical Report No. 71 shall be followed when specifing packaged boilers.

Boiler efficiency and capacity shall be tested in accordance with ASME PTC 4.1. The "Input-Output (direct) Method" of measuring boiler efficiency and capacity in ASME PTC 4.1 shall be used. In the case of boilers 5 million BTU per hour or less, the "Short-Form (indirect) Method" in ASME PTC 4.1 is acceptable when radiation and other losses are calculated in accordance with charts obtained from ABMA. Under test conditions, the minimum acceptable boiler efficiencies shall be as shown in FCC Technical Report No. 71, Table 3.

1555-2.2 Package-Type Versus Field-Erected Boilers

An LCC analysis shall be performed to determine whether to select a field-erected or a package-type boiler.

Field-erected boilers shall provide for furnace volumes adequate under continuous operation to comply with Table 1555-2.2. Criteria prescribed in FCC Technical Report No. 51 shall apply to package and field-erected boilers.

1555-2.3 Comparison of Steam and High-Temperature Water Systems

In determining whether to select a steam or HTW system, the following factors shall be considered as a minimum:

- Whether the system will be operated intermittently or continuously

- Whether fast response to significant load variation is important

- Pumping costs
- Length, size, and configuration of piping required
- LCC
- In a facility where a few of the processes require steam, the possibility of using HTW to generate the steam at its point of use

1555-2.4 Steam Generation Units

Steam boiler ratings shall comply with the recommendations in FCC Technical Report No. 44.

Boilers shall be designed to provide dry, saturated steam unless specific economic requirements for electric generation, process requirements, or extensive distribution systems require superheated steam.

If required for process, the use of high-pressure satellite boilers located close to the high-pressure process requirement shall be considered in lieu of distribution of high pressure steam.

1555-2.5 High-Temperature Water Generation Units

1555-2.5.1 Definition

A HTW system is a system that generates beating or process water in excess of 300°F.

1555-2.5.2 General

HTW boilers shall be of the controlled forced-circulation type, specifically designed for high-temperature water service, in accordance with FCC Technical Report No. 37.

Table 1555-2.2 Field-Erected Boiler Continuous Heat Release Rates (BTU/Hr/Cubic Foot of Furnace Volume)

Field-Erected Boiler Type	Heat Release Rate
Pulverized Coal	15,000 to 30,000
Gas/Oil	20,000 to 30,000
Oil	25,000 to 30,000
Gas	20,000 to 30,000
Spreader Stoker	25,000 to 35,000
Single-Retort Stoker	30,000 to 40,000
Multiple-Retort Stoker	30,000 to 30,000
Chain-Grate Stoker	40,000 to 55,000
Traveling-Grate Stoker	40,000 to 55,000

Because of costs associated with high-pressure pipe, valves, and fittings, HTW systems should not be designed for temperatures and pressures higher than absolutely necessary.

1555.2.5.3 System Pressurization

In a gas-pressurized HTW system, an inert gas such as nitrogen shall be used, and the pressurizing tank shall be installed vertically to reduce the area of contact between gas and water, thus reducing the absorption of gas into the liquid.

Gas-pressurized systems should be maintained at a pressure well above the pressure at which the HTW will flash to steam.

Pump pressurization is generally restricted to small process heating systems. In larger HTW systems, pump pressurization can be combined with gas pressurization.

1555-2.5.4 Circulating Pumps

The energy efficiency of circulation pumps shall be emphasized.

In steam-pressurized systems, circulating pumps shall be located in the supply lines to maintain pressure above the flashpoint of the hottest water in the distribution system.

A mixing connection that bypasses some of the cool return water into the supply line at the pump suction shall be provided to safeguard against flashing or cavitation at the pump(s).

In a gas-pressurized HTW system, the circulating pumps may be installed in either the supply or return lines.

1555-2.6 Associated Systems for Steam and High-Temperature Water Generation

1555-2.6.1 Fuel Storage and Handling Systems

Fuel storage and handling shall comply with the recommendations in FCC Technical Report No. 51, Chapter III, Sections 2.0, 3.0, and 4.0.

Control, containment, and treatment of rainwater runoff from coal storage yards shall comply with effluent guidelines and standards for steam-electric power generating point sources, 40 CFR 423.

The relative economy of a central natural gas-fired plant compared to a gas distribution system serving the individual requirements of each building shall be considered.

The long-range availability of the gas supply and the possible need for a secondary fuel shall be established. The economics of interruptible versus uninterruptible gas service relative to availability of a secondary fuel shall be considered.

1555-2.6.2 Fuel Burning Systems

Fully automatic mechaniml-firing equipment and mechanical draft equipment shall be provided. Mechanical-firing equipment shall be specified to develop 100 percent to 125 percent of the boiler capacity. Fuel burning systems shall comply with FCC Technical Report No. 51, Chapter III, Section 8.0.

1555-2.6.3 Ash Handling Systems

Ash handling systems shall comply with FCC Technical Report No. 51, Chapter III, Section 3.1.

Land availability for storage or disposal, water availability, nearness to residential areas, the possibility of the sale of ash as a means of disposal, and environmental regulations shall be considered.

Collection and treatment of ash-carrying liquid effluents shall comply with 40 CFR 423.

1555-2.6.4 Combustion Auxiliaries

Combustion auxiliaries shall comply with FCC Technical Report No. 51, Chapter III, Section 5.0.

1555-2.6.5 Boiler Water Treatment

Boiler water treatment shall be provided to prevent deposits on or corrosion of internal boiler surfaces and to prevent the carry-over of boiler water solids into the steam.

A boiler water treatment specialist shall be consulted in determining corrective treatment measures. Water quality measures for the steam plant and other site process water users should be coordinated.

The design of the plant shall provide for daily sampling to determine internal water conditions. A small laboratory shall be provided for on-the-spot analyses of the samples and preparation of check samples for outside analyses.

Provisions shall be made for introducing treatment chemicals into the feed water. The plant shall contain adequate space and equipment for storing, handling, and mixing chemicals.

Continuous versus intermittent blowdown operations shall be considered to determine which system will keep the concentration of total solids within acceptable limits. For continuous blowdown operations, the economics of installing a heat recovery system shall be considered.

1555-2.6.6 Boiler Water Makeup

The decision to waste or return condensate shall be based on a consideration of the cost of construction and maintenance of return lines and pumps, the danger of returning contaminated condensate, and the costs of treating and heating make up water. See Section 1555-3.2, Steam Distribution Systems, for additional condensate-line economic considerations.

A minimum of two boiler feed pumps, each sized to handle the peak load, shall be provided to allow one pump to be out of service.

The feasibility of duplicate pumps with different drives (steam turbine, reciprocating steam engine, or electric motor) shall be considered.

Pumps shall be equipped with automatic controls to regulate feed water flow to maintain required water level range, and with a relief valve preset to lift at lower pressure than the boiler safety valve setting plus static and friction heads.

1555-2.6.7 Boiler Room Controls and Instrumentation

Boiler plant instrumentation and control panels shall include devices for monitoring the combustion process and consoles in which such devices are mounted. Combustion controls shall comply with "improved risk" criteria as defined in DOE 5480.7.

Boiler room controls and instrumentation shall comply with the appropriate standard from among NFPA 85A, NFPA 85B, NFPA 85D, and NFPA 85E.

1555-2.6.8 Plant Insulation

All hot surfaces within 7 feet of the plant floor or any catwalk shall be insulated to prevent surface temperatures above 140°F where contact would be inadvertent and 120°F where contact is likely or necessary for equipment operation. Insulation shall be in accordance with the manufacturer's recommendations and ASHRAE Fundamentals handbook. See also Section 1525-4, Safe Surface Temperatures

1555-3 STEAM AND HIGH-TEMPERATURE WATER DISTRIBUTION

1555-3.1 General

Steam and HTW distribution systems shall be sized to accommodate future expansion without extensive modification.

An economic comparative cost analysis shall be made to determine whether to run distribution piping aboveground or underground by direct burial in conduits, trenches, or tunnels.

When aboveground steam or HTW distribution systems are to be constructed, pipe shall be installed on concrete pedestals, concrete/steel stanchions, or on poles. Where piping crosses over roadways, a minimum of 14 feet of clearance shall be provided.

Provisions shall be made for expansion and contraction in the piping system. Expansion loops shall be provided where space allows. Where space does not allow, expansion joints may be used. Expansion joints shall be limited to the packless bellows-type joints or ball joints.

Piping shall comply with ASME B31.1.

1555-3.2 Steam Distribution Systems

Steam shall be supplied to the distribution system at the lowest pressure that will adequately serve the connected load unless economics dictate otherwise. The economics of higher pressure distribution shall be considered. Processes requiring higher pressures shall be serviced, where practical, by a separate section of the distribution system to avoid operating the entire system at pressures higher than necessary.

Warmup bypass valves shall be provided at all shutoff valves in steam distribution lines. Steam velocities shall be selected for the type of service being considered, but shall not exceed 10,000 feet per minute.

Steam and condensate pipe shall, where possible, be graded a minimum of 1 inch in 40 feet in the direction of flow. Drip stations and steam traps shall be provided at all low points in steam lines.

To assure tightness of the steam system, all joints to valves and fittings for sizes larger than 1-1/4 inches shall be welded, except in the boiler house, where flanges shall be used to facilitate maintenance of equipment, connections, or valves.

The decision to use more expensive corrosion-resistant materials or heavier schedule pipe for condensate return systems shall be considered against the cost of corrective chemical treatment of boiler water. Where soil and climatic conditions allow, underground condensate lines may be coated or wrapped, installed separate from steam lines, and buried directly without insulation. Where the potential for severe corrosion exists, the need for cathodic protection should be examined, and the cost shall be one of the economic factors used to determine if condensate should be returned or wasted as discussed in Section 1555-2.6.6, Boiler Water Makeup.

1555-3.3 HTW Distribution Systems

HTW piping shall be sized for an average velocity of 5 feet per second, a maximum velocity of 10 feet per second, and a minimum velocity of 2 feet per second. HTW piping shall be sized so that each zone or circuit has equal friction loss.

To assure tightness of the HTW system, all joints to valves and fittings for sizes larger than 1-1/4 inches shall be welded, except in the boiler house, where flanges shall be used to facilitate maintenance at equipment connections and valves.

Unlike steam piping, HTW piping may follow the natural terrain; however, proper provisions shall be made to drain and vent the piping.

1555-3.4 Piping Insulation

Insulation containing asbestos materials shall be prohibited.

Insulation thickness of exterior above-ground and underground distribution systems and equipment shall be based on the TIMA Economic Thickness Manual.

The possibility that water infiltration will cause physical damage or loss of thermal characteristics of underground pipe insulation shall be considered in the selection of insulation.

All insulation installed aboveground, in tunnels, and in manholes shall be provided with a metal jacket, either factory or field installed, or provided with a hard cement finish.

1565 REFRIGERATION

1565-1 CHLOROFLUORCARBON (CFC) LIMITATION AS A REFRIGERANT

1565-1.1 Coverage

These criteria provide guidance to reduce DOE dependence on regulated CFCs as refrigerants in HVAC systems. CFC-22 is the only refrigerant in common use for HVAC systems not subject to international regulation due to environmental concerns (ozone depletion). Production of regulated CFCs (CFC-11, CFC-12, CFC-113, CFC-114, CFC-115, and, indirectly, refrigerant mixtures of those regulated CFCs such as CFC-500, CFC-501, and CFC-502) will be reduced 50 percent by 1993, with corresponding reduction of availability and increase in cost. Requirements to recycle and recover these regulated CFCs is expected in the near future. Continued installation of HVAC systems using regulated CFCs is unacceptable from operational and environmental viewpoints and shall be minimized to the maximum extent feasible.

Alternatives to CFC-11 and CFC-12 are being developed for use in existing equipment and future new equipment; however, significant technical problems have yet to be overcome. As technically proven alternative refrigerants become commercially available, these criteria will be updated to include their application. With present technology, the only feasible course to reduce DOE HVAC dependence on regulated CFCs is to limit new equipment to unregulated CFCs (CFC-22) where feasible and replace the existing inventory with equipment designed for CFC-22 as existing units fail.

1565-1.2 Effective Date

These criteria are to be implemented as of the date of this Order. Application is as follows:

- Projects in planning or programming and those in Title I design or less: Comply with these criteria.

- Projects in Title II design and those under construction: Implement where technically and economically feasible.

1565-1.3 Implementation

These criteria require immediate implementation to reduce DOE dependence on regulated CFCs to a minimum. The limitation of refrigerants to CFC-22 will be reviewed and relaxed to include alternative environmentally acceptable refrigerants as they become available. These criteria limit the use of CFCs in DOE design and construction and operations and maintenance programs to nonregulated compounds as follows:

- New mechanical refrigeration equipment: Use CFC-22 as the refrigerant where feasible.

- Repair-by-replacement projects involving the complete refrigerant side of existing equipment: The replacement equipment shall use CFC-22 as the refrigerant.

1565-1.4 Exceptions

Exceptions shall be as follows:

- New absorption equipment or replacing existing equipment with absorption equipment

- Equipment in size ranges where CFC-22 equipment is not commercially available by a minimum of two suppliers with adequate operational experience. All available equipment types (reciprocating, helical screw, and centrifugal) shall be considered before making this decision.

- Repair projects involving partial replacement of the refrigerant side of a system, such as compressor or coil replacement only can use the existing refrigerant.

1574 CRYOGENIC SYSTEMS

1574-1 COVERAGE

These criteria shall apply to cryogenics as defined by the NBS, that is, involving temperatures below 120°K (-124°F). Systems involving hydrogen and methane are not covered by these criteria. Systems involving oxygen and fluorine (because of their reactivity) may require special design and cleanliness requirements in addition to these basic criteria.

1574-2 SYSTEM DESIGN

1574-2.1 General

Liquefaction plants for DOE facilities shall be designed, supplied, and installed by experienced manufacturers specializing in complete, installed, and fully tested systems. All components shall be furnished and assembled by a single responsible contractor or manufacturer. Specifications for these systems shall be performance-based. Liquid and gas production rates, purity, storage volumes, and special equipment features and materials to be supplied shall be specified.

1574-2.2 Compressors

1574-2.2.1 Screw or Lobe Compressors

Screw or lobe compressors shall be considered when the following characteristics are desired:

- Low specific weight and space requirements

- Low orders of vibration or pulsation

- Positive displacement without surge limitations

- Low maintenance

To reduce oil carryover to less than 1 ppm charcoal filters, oil separators, absorbers and/or coalescers should be specified.

1574-2.2.2 Reciprocating Compressors

For continuous service, first consideration shall be given to water-coded, heavy-duty, long-life, low-maintenance reciprocating compressors. Lighter, higher-speed air-cooled types shall be considered for mobile or intermittent duty. Non-lubricated compressors shall be considered in terms of the cost of oil removal systems where oil free gas is required. A hermetic type compressor with heavy duty water cooling should be considered when impressing low molecular weight gases.

1574-2.2.3 Centrifugal Compressors

Centrifugal compressors should normally be used as the main air supply for separation plants. These should be equipped with adjustable inlet guide vanes to facilitate capacity reduction.

1574-2.2.4 High-Pressure Centrifugal Compressors

Vertically split case compressors shall be considered to produce output pressure in the range 2000-3000 psig. The design professional shall pay particular attention to shaft seal type and application when this type of compressor is used. These machines should not be specified for service on low molecular weight gases.

1574-2.2.5 Axial Compressors

Gas or steam-turbine driven axial compressors shall be considered for the main air supply to very large plants. They have capacities of approximately 120,000 ACFM at 100 psig.

1574-2.2.6 Diaphragm Compressors

A diaphragm compressor shall be considered for applications requiring relatively low flow rates (5 to 60 cfm) and discharge pressures up to 15,000 psig, where it is especially important that the gas being processed not come into contact with any lubricant.

1574-2.2.7 Multistage Compressors

Where high capacity and high pressure service is required, (up to 20,000 scfm and 3000 psig discharge pressure) the design professional should combine compressor types in a multistage configuration. Centrifugal or screw compressors are appropriate for lower stages with reciprocating compressors used for higher pressure stages.

1574-2.2.8 Compressor Support and Isolation

Large compressors used in conjunction with a liquefier or refrigerator and its driver shall be properly aligned and isolated from the building structural members. The manufacturer’s standard foundation design shall be considered in the context of local soil conditions and modified as appropriate.

1574-2.3 Pumps

1575-2.3.1 Axial-Piston Pumps

Axial-piston pumps shall be considered for transferring cryogenic fluids at high pressure and low flow rate. Piston seals and frictional energy dissipation are disadvantages to be considered in design applications.

1574-2.3.2 Centrifugal Pumps

Centrifugal pumps should be used for transferring cryogenic fluids at high flow rate and low discharge head. Disadvantages include higher frequency of shaft bearing and seal failure.

1574-2.3.3 Pressure Vessel Pumping

Consideration should also be given to transferring cryogenic fluids using pressurizing tanks as transfer pumps. Batch transfer of cryogens may use vaporizers in combination with tanks or dual tank systems with internal heating.

1574-2.4 Vaporizers

1574-2.4.1 Ambient Air Vaporizers

Ambient air vaporizers work well at ambient temperatures greater than 244°K (-20°F). Electric defrost may be required to prevent ice-over. They shall be used only as part of a system containing other vaporizers.

1574-2.4.2 Forced-Flow Ambient Air Vaporizers

Automatic electric defrost shall be considered for forced-flow ambient air vaporizers depending on intended use cycles.

1574-2.4.3 Electric Vaporizers

Electric vaporizers are simple, compact, and capable of handling very high flow rates (up to 500,000 scfm). Electric vaporizers shall be provided with safety interlocks for protection during power outage.

Electrical demand and power consumption can be very high for these units.

1574-2.4.4 Steam Vaporizers

Steam vaporizers are complex relative to the electric units and are subject to freezing if steam supply is interrupted or flow is inadequate. These shall be used only for special applications.

1574-2.5 Storage Vessels

1574-2.5.1 General

Section VIII of the ASME Boiler and Pressure Vessel Code shall be used in specifying the design of the cryogen storage vessel that is inside another vessel that serves as a vacuum jacket. For classification of cryogenic storage vessels and recommended vessel insulation for various fluids, sizes, and application see ASHRAE Applications handbook, Chapter 38, Table 11.

1574-2.5.2 Inner Vessel Design

The inner vessel shall be designed according to the rules for vessels under internal pressure loading. To provide for boil-off, a minimum 10 percent ullage (i.e., the amount a vessel lacks of being full) shall be used. Vacuum jacketed storage vessels shall be equipped with two pressure relief devices: one for use under normal conditions and a second, larger one to protect the vessel from the rapid boil-off that would occur in the event of a sudden loss of vacuum. If the inner vessel is to be contained within a vacuum vessel, an additional 14.7 psi shall be added to the design working pressure for the inner vessel.

Materials used for the inner vessel that contains the cryogen shall be suitable for the temperatures encountered, and not be brittle. Austenitic stainless steel (AISI 300 Series) and aluminum shall be the principal materials used.

1574-2.5.3 Outer Vessel Design

The outer vessel shall be designed according to the rules for failure by elastic instability rather than excessive stress. Pressure relief devices shall be provided to protect the vacuum jacket from large positive pressures that could result from small leaks from the inner vessel containing the cryogen into the vacuum jacket and for the case of complete inner vessel failure.

1574-2.6 Instrumentation and Control

Advantages and disadvantages of the various generic types of temperature, pressure, flow, and liquid level instrumentation and control devices are listed in Tables 6-1 through 6-8 of TM-5-810-7/AFM 88-12, Chapter 4.

1574-2.7 Piping and Fittings

The low temperatures in cryogenic systems present problems not commonly encountered in other systems. The following shall be considered when specifying and designing piping systems:

- Lines partly filled with a liquid cryogen are subject to upward bowing. This occurs when the wetted bottom of the pipe is much colder than the unwetted top portion, and differential thermal expansion causes the pipe to rise between supports. Restraints shall be designed to withstand this phenomenon.

- Cryogenic piping materials shall be suitable for the temperatures encountered, and they shall not be brittle. Austenitic stainless steel (AISI 300 Series) and copper shall be used. Stainless steel pipe shall comply with ASTM A312 Type 304 or 316. If schedule 5S or 10S pipe is specified it shall be reinforced at the anchor attachment points if loads exceed one kip. In very special circumstances, aluminum or titanium alloy piping may be appropriate.

- Due to weight of extended stems, bonnets, and operators, support requirements for cryogenic valves shall be carefully analyzed, and if necessary valves shall be supported separately from piping. Depending on operator weight, separate, flexible mounting of operators may be required.

- Pipelines shall be sized for both cool down requirements and steady state conditions.

- Cryogenic valves shall be of the slow opening type.

- Cryogenic piping sections between shut off valves shall include relief devices to allow for venting of trapped cryogen boil-off vapors. Relief devices should be redundant and each of different design.

1574-2.8 Joining Methods

1574-2.8.1 Welded Joints

Welded joints and silver brazed joints shall be used except where disassembly is required. The design and inspection requirements shall comply with ASME B31.1 or ASME B31.3.

1574-2.8.2 Reweldable Joints

Reweldable joints featuring an outer can welded to sealed closure rings shall be used where periodic but infrequent disassembly is required.

1574-2.8.3 Bayonet Joints

High-performance bayonet joints shall be used where frequent disassembly is required.

1574-2.8.4 Flanged Joints

Where possible, flanged joints shall be avoided due to high thermal stresses introduced within the flange assembly during cooldown.

1574-2.8.5 Compression Joints

Compression joints may be used for small bore tubing, but shall not be used for high pressure service (downstream for positive displacement pumps, for example).

1574-2.8.6 Copper Shear Seals

Copper shear seals shall be used for larger diameter tubing.

1574-2.8.7 Vacuum Seals

Either single or double O-ring elastomer seals shall be used for most general vacuum installations because of their availability and low cost. For ultrahigh vacuum systems, metallic seals shall be used.

1574-2.8.8 Transition Couplings

Transition couplings shall be used to join aluminum and stainless steel piping in cryogenic systems, e.g., where aluminum heat exchangers are used.

1574-2.9 Valves and Pressure Relief Devices

Extended stem valves shall be used to allow ambient temperature stem packing and minimize heat leakage in vacuum jacketed valves.

Valve materials selection shall ensure ductility, minimum heat influx, and gasket compatibility with cryogenic fluid temperature extremes. For a comprehensive guide to valve selection consult TM 5-810-7, Table 4-6. Pressure relief devices shall comply with ASME Boiler and Pressure Vessel Code, Section VIII, ASME B31.1 or ASME B31.3 as applicable, and CGA Pamphlet S-1.1, CGA Pamphlet S-1.2, and CGA Pamphlet S-1.3. Devices shall be code certified. Relief devices shall be installed on stainless steel risers at least 8 inches from the pipe or component they are designed to protect.

1574-2.10 Miscellaneous Materials

Bolts, gaskets, pipe, fittings, castings, and forgings for temperatures from -20°F to -150°F shall comply with TM 5-810-7/AFM 88-12, Tables 4-7 through 4-9.

1574-2.11 Insulation

Except when equipment is located outside of buildings, all insulation material, media used to apply insulation, and jacketing material shall have a maximum flame spread of 25 and maximum smoke development of 50 when tested using UL 723 Test Methods.

The following insulation methods for exterior application to cryogenic equipment are listed in order of increasing cost and increasing effectiveness:

1. expanded foams
2. gas-filled powders
3. gas-filled fibers (loosely compacted fibrous insulation)
4. vacuum alone (both static and dynamic vacuum systems)
5. vacuum with powder
6. vacuum with opacified powders
7. vacuum with multilayer insulation

Non-vacuum insulating systems should generally be specified for short-term storage and transfer of less volatile liquids, storage of larger quantifies such as in field-erected tanks and production plants. Evacuated systems should be specified for long-term storage of more volatile fluids, especially of small quantities.

A good vapor barrier shall be used to prevent air and moisture from diffusing through the insulation when using expanded foams, gas-filial powders, or gas-filled fibers. Insulation or expanded metal shall be used to protect personnel from cold piping and equipment.

1574-3 FACILITY SITING AND EQUIPMENT INSTALLATION

1574-3.1 General

Installation of cryogenic oxygen systems shall comply with NFPA 50. Liquid nitrogen and helium systems shall comply with CGA Pamphlet P-1.

1574-3.2 Siting

Siting considerations shall include:

- Noise levels during facility operation
- Proximity to public roads and public land
- Spill consequences
- Adequate maintenance access and staging space
- Accessibility to cranes and other heavy equipment
- Adjacent clear space to allow future plant capacity increase

The requirement for liquefaction towers and associated equipment to be within buildings shall be considered for cost effectiveness based on geographic siting and anticipated use cycles. When liquefaction towers and associated equipment and controls are to be located within buildings they shall be in a dedicated area. Bulk storage tanks may be located above ground outdoors or indoors. Buildings or catch basins housing bulk oxygen tanks or oxygen generation equipment shall be of fire resistive, noncombustible, or limited-combustible construction, adequately vented, and used exclusively for that purpose.

Relief devices shall be located away from walkways and normally or potentially occupied areas and at angles to avoid injury due to release of cryogens.

1574-3.3 Noise

Acoustical control and structural considerations for vibrating equipment shall comply with DOE 5480.1B.

1574-3.4 Spills

Cryogen "burns" can result from direct contact with either a cryogen or uninsulated piping or equipment containing a cryogen. The large evolution of gases associated with the cryogenic spill can result in asphyxiation. Facilities that will house cryogenic storage vessels shall have collection sumps, adequate ventilation equipment for controlling vaporization pressurization and precluding asphyxiation, oxygen deficiency alarms, and rapid means of egress.

Air can contaminate the cryogen, creating a potential explosive either directly as when air mixes with liquid hydrogen or liquid methane, or indirectly by transforming an inert cryogen such as liquid nitrogen into an oxidant (a potential hazard for combustible insulation). When liquid oxygen spills on asphalt it tends to cause the asphalt to explode. When cryogen falls on concrete it tends to spall. A 6-inch layer of crushed stone shall be placed in areas where a cryogenic spill could occur.

1574-4 QUALITY ASSURANCE

1574-4.1 General

The special hazards inherent with cryogenic system make quality assurance in design, cleaning, and testing extremely important. In addition to special requirements listed herein, quality assurance shall be in accordance with DOE 5700.6B.

1574-4.2 Cleaning

Cleaning procedures shall include, as a minimum, blowdown, flushing, decreasing, drying, and standby pressurization. For cleaning standards consult CGA Pamphlet G-4.1, CGA Pamphlet G-4.4, MIL-STD-1330 and MIL-STD-1630, and NASA SP-3072.

1574-4.3 Testing

Cryogenic components and systems shall be tested prior to acceptance. Piping and piping components shall be tested per ASME B31.3, and vessels per ASME Boiler and Pressure Vessel Code, Section VIII. Testing shall include, but not be limited to, thermal shock, thermal performance, pressure, leakage, welding quality, and vacuum retention.

1574-5 SAFETY REVIEW

All cryogenic systems shall be subjected to a safety review in accordance with DOE 5481.1B. These considerations must include the potential for ODHs. All cryogenic systems shall be categorized as a minimum of "low hazard" as defined in DOE 5481.1B unless sufficient analysis has been done to justify a lower classification.

1589 AIR POLLUTION CONTROL

1589-1 GENERAL

These criteria shall be applied to the control, treatment, and subsequent disposal of all airborne and gaseous wastes to assure compliance with the following:

- DOE 5400.1
- DOE 5440.lC.
- DOE 5480.4
- Federal, State and local standards including restrictions on sulfur content of fuel and other requirements specifically related to the control of air pollutants, as referred to in Executive Order 12088

1589-2 IMPROVED RISK CONCEPT

At a minimum, facility confinement systems, including filters and ventilation systems, shall comply with the "improved risk" criteria defined in DOE 5480.7 and shall preclude offsite release of greater than TLV amounts of toxic materials during the maximum credible fire loss conditions. As defined in DOE 5480.7, "maximum credible fire loss" is the maximum loss that could occur from a combination of events resulting from a single fire assuming installed fire protection systems function as designed. The effect of emergency response (i.e., manual fire fighting actions) is generally omitted except for post-fire actions.

1589-3 PLANNING FOR AIR POLLUTION CONTROL

Air pollution control planning shall include:

- Identification of potential sources of air pollution
- Analysis of the characteristics of the pollutants and the feasibility of conversion to usable or salable products
- Analysis of alternative methods available for control and treatment of emissions
- Consideration of alternative methods of ultimate disposal of wastes

Priority shall be given to the potentials for conservation and recovery of resources. The technical and economic feasibility of conversion systems for recovery of usable products shall be determined during the planning or early design phase for a project. The potential adverse environmental impacts on land and water shall also be taken into account.

Any system that may discharge dust, fumes, gases, or other contaminants to the environment shall be considered in terms of applicable regulations or standards.

These include the following:

- Combustion process installations
- Incinerators
- Volatile product storage facilities
- Fume exhaust systems

1589-4 COMBUSTION PROCESS INSTALLATIONS

1589-4.1 Selection of Fuel

Fuel selection for heat-generating equipment shall comply with DOE 4330.2C. General guidance on effects of fuel choice on air pollution is contained in FCC Technical Report No. 57. Fuel choice shall be made on the basis of economic analysis, weighing the added cost of pollution control equipment as well as sulfur removal against cheaper coals and oils of high sulfur and nitrogen content.

1589-4.2 Firing Equipment

All combustion process systems shall have fully automatic firing, and shall be installed in accordance with manufacturer's recommendations. Stoker-fired installations shall provide for over-fire, secondary air jets controlled by a photoelectric smoke-detecting device.

Combustion process equipment shall comply with NFPA 30, NFPA 31, NFPA 54, NFPA 85A, NFPA 85B, NFPA 85D, NFPA 85E, NFPA 85F, and NFPA 85G for the appropriate fuel and equipment type.

Combustion controls to maintain proper fuel/air ratio shall be provided for firing equipment regardless of design, capacity, or fuel burned. The design and construction of firing equipment, or equipment conversions, shall ensure that the necessary burning time, temperature, turbulence, and fuel-air ratio are maintained to minimize hydrocarbon components in the flue gas. Combustion controls shall comply with "improved risk" criteria defined in DOE 5480.7.

Equipment shall reduce NO_x emissions below permissible levels with combustion refinements such as:

- Two-stage (off-stoichiometric) combustion
- Low-excess-air operation
- Gas recirculation in the combustion zone (oil- and gas-fired units)
- Use of dual-register burner for delayed air and fuel mixing

1589-4.3 Draft Auxiliaries

Combustion products from gas-, oil-, or solid fuel-fired installations shall be discharged to the atmosphere at sufficient height and in such manner as to maximize the dispersion of stack effluent. Requirements for dispersing stack effluent may frequently influence the selection of natural draft rather than mechanical draft methods. Determination of discharge height shall be based on:

- Air quality criteria
- Land use
- Meteorology
- Aesthetics
- Operating parameters

Exhaust stack height shall comply with:

- EPA 600/8-81-009
- EPA 450/4-80-023
- EPA 450/4-81/003

1589-4.4 Emission Detectors

CEM systems for measuring the opacity of emissions, sulfur dioxide emissions, NO_x emissions, and either oxygen or carbon dioxide for fossil-fuel fired equipment are required for most operations under current NSPS.

All coal- and oil-fired combustion equipment shall be equipped with continuous emission opacity monitors and alarms. See Section 1589-4.2, Firing Equipment, for use of a smoke detector to control over-fire jets.

Opacity monitors may be traditional photoelectric or feature fiberoptic cable to connect transmitter and receiver. All components that must be cleaned shall be accessible.

Flue gas monitors may be extractive (gas sample removed from stack for analysis) or in-situ (analyzer mounted on the stack with sampling apparatus directly in contact with flue gas).

Sulfur dioxide and NO_x are traditionally analyzed by instruments that rely on ultraviolet light. Recent developments in analyzer technology have presented other options such as:

- Electrochemical cell analyzers
- Pulsed fluorescent analyzers
- Chemiluminescent analyzers

Because of rapidly changing technology, direction cannot be given for specification of emissions monitoring equipment. Instruments shall be selected after consideration of advantages and disadvantages of each type of device.

1589-4.5 Coal and Ash Handling

Systems for storage and handling of coal and ash shall prevent the release of significant quantities of dust to the atmosphere. Dust collectors shall be located at vents on pneumatic ash handling systems as well as at material transfer points such as:

- Car dumper
- Sample house
- Crusher house
- Reclaim tunnel
- Conveyor room

Conveyor transfer towers and car dumpers shall be totally enclosed. Telescoping chutes shall be used where applicable. Support structures shall have concrete floors with drains to facilitate washdown.

Conveyor enclosures shall be designed to minimize exposed structural steel where dust can accumulate. Openings in building upper floors shall be curbed. Drain trenches shall be designed for positive cleanout. (Conditioning/agglomeration systems shall be considered where dust from dust collectors is being re-entrained at the conveyors.

Dust collection equipment for coal and ash shall be selected from recommended collector types in ACGIH Industrial Ventilation Manual, Figures 11-18. Coal and ash handling equipment shall comply with NFPA 68, NFPA 85E, and NFPA 85F as appropriate.

1589-4.6 Facilities for Testing

Access openings, platforms, ladders, man lifts, or elevators shall be provided for periodic testing of combustion equipment. Instrumentation shall be accessible for cleaning and easily removable for repair.

1589-5 REFUSE DISPOSAL FACILITIES

1589-5.1 Incinerators

Incinerators for refuse disposal shall burn efficiently with minimum environmental impact based on best available technology. Air emissions shall meet or exceed the requirements of the air quality permit for the State in which it is located. If the State does not have a vested air quality program, the incinerator shall be required to meet Federal standards. The manufacturer shall be required to submit, with its quotation, certified test results for similar incinerators demonstrating experience meeting applicable standards and regulations.

Incinerators used to dispose of toxic or other hazardous waste shall comply with 40 CFR 260, et seq, and Subpart O of 40 CFR 264. Sufficient incinerator capacity shall be provided to ensure adequate pollution control capabilities. Emission control and monitoring features, as well as firing-rate limit controls, shall prevent operation in excess of design capacity.

Incinerators shall be considered as a means of thermal energy generation, particularly those handling large volumes of waste. The use of wet process destructors, pulverizers, shredders, and compactors as alternatives to incineration shall be considered for disposal of paper wastes. These methods shall be for disposal of classified paper wastes only with the approval of the cognizant DOE security officer.

1589-5.2 Off-Site Disposal

Nearby public and commercial disposal facility capabilities shall be considered and used if economically and operationally feasible. Such facilities shall comply with applicable air and water quality standards, regulations, and permit requirements.

1589-5.3 Landfill and Dumping

Any land disposal shall comply with RCRA, as amended, and implementing regulations in 40 CFR 241, et seq. The appropriate State environmental agency or regional EPA office shall be consulted when wastes will be generated and not incinerated.

1589-6 GAS-CLEANING EQUIPMENT AND EMISSION CONTROL DEVICES

1589-6.1 Gases

Oxides of nitrogen are controlled by combustion refinements as discussed in 1589-4.2, Firing Equipment.

Since flue-gas desulfurization technology is changing rapidly, a single criterion for choosing a flue-gas desulfurization process cannot be given. In keeping with previous criteria, the system shall be chosen based on economic analysis among those systems that satisfy current emissions requirements.

1589-6.2 Particulates

Selection of an air cleaning device for a given particulate shall be based on the recommendation of the ASHRAE Equipment handbook, Section I, Chapter II, Industrial Gas Cleaning and Air Pollution Control, and ACGIH Industrial Ventilation Manual. Equipment shall be selected to achieve removal efficiencies that will produce emissions within applicable Federal, State, or local regulations.

1589-7 STORAGE FACILITIES FOR VOLATILE LIQUIDS

Vapor emission control devices shall be installed on volatile liquid storage facilities as required. Submerged fill-piping shall be provided on new storage tanks. Compliance with CAA, RCRA and other State, regional or local requirements shall also be satisfied.

1589-99 SPECIAL FACILITIES

1589-99.0 Nonreaetor Nuclear Facilities-General

1589-99.0.1 Radioactive Airborne Effluents

All airborne effluents from confinement areas shall be exhausted through a ventilation system designed to remove particulate material, vapors, and gases as needed to comply with the guidance provided in Section 1300-1.4.3, Routine Releases, and, if other hazardous materials are additionally present, with DOE 5400.1. ALARA design principles shall be implemented to minimize effluent concentrations and quantities released for all hazardous materials.

All exhaust ducts (or stacks) that may contain radioactive airborne effluents shall be provided with effluent monitoring systems that are designed in accordance with the applicable requirements contained in the directive on Radiation Protection of the Public and the Environment in the DOE 5400 series and and the directive on Radiological Effluent Monitoring and Environmental Surveillance in the DOE 5400 series. Backup capability for monitoring systems shall be considered in the design of each system (e.g., redundant detectors, additional sample line ports, additional sampler trains, etc). Continuous stack sampling and continuous radiation detection shall be considered. Sampling systems shall be designed in accordance with ANSI N13.1 and associated appendixes to ensure representative sampling of the effluent stream. Isokinetic sampling shall be provided for effluent streams that are expected to contain particulate radionuclides. The range capability of continuous monitors shall rover from routine to potential DBA releases of radionuclides. Nuclear criticality safety shall be considered in the design of equipment used to treat and discharge radioactive airborne effluents.

1589-99.0.2 Nonradioactive Airborne Effluents

For nonradioactive hazardous gaseous or airborne effluents, the point of release shall be considered the point at which the effluent exits the stack, vent, etc. Nonradioactive gaseous or airborne effluent releases shall not exceed the guidelines contained in DOE 5400.1 and shall comply with all other applicable Federal, State, and local requirements. To the extent practical, ALARA principles shall be applied to minimize adverse impacts to the public and the environment.

1595 CONTROLS

1595-1 GENERAL

This section covers safety and operating controls, automatic temperature and humidity controls, energy monitoring and (central supervisory) control systems, energy conservation requirements for controls, and inning requirements and restrictions.

Specific safety control system requirements for individual types of equipment are discussed in Section 1550, Heating, Ventilating and Air-Conditioning Systems. Lighting, security, and fire protection control systems related to central supervisory control systems are discussed in Section 0110-12, Energy Conservation, and Division 16, Electrical.

Special control requirements shall be indicated in DOE project-specific criteria. Selection of control system types and associated equipment, shall be based on the most economical and maintainable system.

Control systems shall be designed to use the closed-loop feedback method of control. Open-loop systems shall not be used. Proportional-type control shall be used for all control systems; other type control systems shall be used as needed according to the degree of control required.

All control equipment shall be easily accessible. One temperature control panel shall he provided for each system, complete with panel-face-mounted indicators, switches, pilot lights, and tags. All control interlocks shall be through HOA switches.

Control air compressors shall be duplex non-lubricated type with oil lubricated crankcase and distance piece. Air shall be filtered and dried using refrigerated air dryers for dew point of 15°F and regenerative silica type for dew point below 15°F.

Copper piping shall be used for high pressure air in inaccessible locations (plastic piping may be used if installed in conduit). Air leakage shall not exceed 5 percent of pressure in 24 hours. Transmitters shall be capable of field calibration and thermometers or pressure gauges shall be provided at transmitters. All controllers and thermostats shall be pilot-bleed type.

1595-2 ZONING

Zoning for automatic control of space temperatures, static pressures, humidities, ventilation, smoke and fire detection, security, and lighting shall satisfy health and safety requirements as indicated in DOE project criteria, NFPA 101, space operational and occupancy requirements, and zoning exposure with relation to building size, orientation and configuration.

Zoning requirements are as follows:

- Each HVAC system shall have a separate thermostat for space temperature regulation and a separate humidistat if humidity control is provided.
- No zone shall contain more than a single building floor regardless of floor space.

- Automatic controls shall be provided to shut off heating or cooling to any individual zone.

- Interior zones shall not be combined with external zones.

- Interior space zones shall be placed on separate air handling systems from external, if cost effective. External space zones shall be selected for each individual exposure.

- For office facilities and similar occupancies, each major orientation shall be zoned to have no more than 2,000 square feet of floor area with exterior exposure, and no more than 3,000 square feet of floor area with no exterior exposure.

1595-3 CONTROL SETBACK AND SHUTOFF DEVICES

With the exception of research, process, or other environmentally sensitive spaces identified by DOE project criteria as requiring constant year-round temperature or humidity control, automatic control setback and shutdown devices with manual override feature shall be provided for all HVAC systems. Use of separate or dual setting thermostats, switches, time clocks, or connections for on/off control through EMSs shall be considered for control of air-conditioning to raise cooling setpoint with humidity override during summer unoccupied periods and to control the heating setpoint during winter unoccupied periods.

1595-4 HUMIDITY CONTROL

Summer and winter space or zone humidity control shall be provided only on a space-by-space or zone-by-zone basis and not for the entire central ventilation system unless required for project-specific humidity requirements as stated in the DOE project criteria. No controls shall be provided to dehumidify spaces to below 50-percent relative space humidity or to humidify spaces to greater than 30-percent relative space humidity unless required on a project-specific basis.

1595-5 SIMULTANEOUS HEATING AND COOLING

Simultaneous heating and cooling shall not be used to control comfort conditions within a space by reheating or recoding supply air or by concurrent operation of independent heating and cooling systems serving a common zone except under the following conditions.

- Renewable energy sources are used to control temperature or humidity.

- Project-specific temperature, humidity, or ventilation conditions require simultaneous heating or cooling to prevent space relative humidity from rising above special-space relative humidity requirements.

- Project-specific building construction constraints as determined in DOE project criteria prohibit installation of other types of HVAC systems.

Where simultaneous heating and cooling must be used, the temperature and humidity controls shall be designed to limit energy consumption by the methods given in ASHRAE Standard 90.

1595-6 CONTROL OF AIR HANDLING SYSTEMS

1595-6.1 Mechanical Ventilation Control

All supply, return, and exhaust ventilation systems shall be equipped with automatic and manual control of fan operation to shut off the fan when ventilation is not required. These systems shall also be provided with manual gravity-operated or automatic control of dampers for outside air intake and exhaust or relief to prevent introduction of outside air when ventilation is not required. Systems that circulate air shall be provided with minimum outdoor air damper position control to assure that the minimum outdoor air quantity is being introduced to the system. Automatic dampers should fail open for return air and fail closed for outside air.

1595-6.2 Outdoor Air Cooling Control (Economizer Cycle)

All air handling systems that recirculate air and are used for space cooling shall be designed to automatically use outside air quantities up to 100 percent of the fan system capacity for cooling the space, with the exceptions noted in ASHRAE Standard 90. Economizer cycle control shall not be used for air handling systems where introduction of the additional outside air would actually increase energy consumption.

The economizer-cycle control system shall have a reset feature.

The economizer cycle control system shall be designed with a relief air control cycle to positively relieve the supply air from the space by sequencing return or relief fans or dampers to maintain a constant room static pressure. Systems using the economizer-cycle should be provided with adequate air filtration to handle the quality of the outside air.

1595-6.3 Automatic Control Dampers

Automatic air control dampers shall be specified to be the low-leakage type with a maximum leakage of 6 CFM/Square foot at maximum system velocity of 1500 FPM and 1-inch pressure differential. The dampers shall be opposed-blade type for modulating control, but may be parallel-blade type for two-position control. Dampers shall be sized for at least 20 percent of the total ductwork resistance pressure drop. Return air dampers shall never be sized less than 1500 FPM. Pilot positioners and operators shall be out of airstream.

1595-6.4 Variable-Air-Volume System Fan Control

Variable-air-volume systems shall be designed with control devices to sense ductwork static air pressure and velocity air pressure and control supply fan airflow and static pressure output through modulation of variable inlet vanes, mechanical speed drive controls, or variable frequency electric drive controls. These control systems shall have a minimum of one static pressure sensor mounted in ductwork downstream of the fan and one static pressure controller to vary fan output either through inlet vane, damper, belt modulator, or speed control. Exhaust fans, supply fans, and return or relief fans shall have control devices that interface the operation of the fans to "track" air volumes and maintain fixed minimum outdoor air ventilation requirements.

1595-6.5 Fire and Smoke Detection and Protection Controls

Engineered smoke pressurization and evacuation systems shall comply with the following:

- NFPA 90A
- NFPA 72E
- ASHRAE Manual, Design of Smoke Control Systems for Buildings
- ASHRAE Systems handbook

All air handling systems shall be provided with the smoke and fire protection controls required by NFPA 101.

All supply, return, relief, and exhaust air ventilation systems shall have interlock controls that interface with fire and smoke detection system controls and either turn off or selectively operate fans and dampers to prevent the spread of smoke and fire throughout the building. These controls shall comply with NFPA 90A.

Special exhaust systems shall be designed to include fire and smoke safety controls as required by NFPA 91. Kitchen exhaust ductwork systems shall be designed to include all fire and smoke safety controls as required by NFPA 96.

1595-6.6 Gas-Fired Air Handling Unit Control

Gas-fired air handling units shall be specified with operating limit, safety controls, and combustion control systems.

Gas burner and combustion controls shall comply with FM Loss Prevention Data Sheets and be listed in the FM Approval Guide. Gas-fired air handling units shall be specified with controls to lock out the gas supply in the following conditions:

- Main or pilot flame failure
- Unsafe discharge temperature (high-limit)
- High or low gas pressure
- No proof of air flow over heat exchanger
- Combustion air loss
- Loss of control system actuating energy

1595-7 CONTROL OF CHILLED WATER AND HOT WATER DISTRIBUTION SYSTEMS

1595-7.1 Zone Control/Distribution System Control

Each zone or air handling system shall be designed with individual terminal unit valved control. Use of either two-way or three-way valves shall be considered based on part-load pump performance requirements and potential pump bhp savings. If the pumping system brake horsepower is greater than 20 bhp, an LCC analysis of variable speed pumping control shall be performed.

Water systems that vary the load to the terminal devices by varying water flow rates using two-way control valves shall be provided with differential pressure controls to reduce system pressure build-up and save energy. These controls shall either signal control valves to route water flow around terminal devices, signal variable-speed pumping controls to reduce pump speed, or turn off one or several pumps working in parallel or series.

1595-7.2 Control Valve Selection

Temperature control valves shall be either two-way or three-way, two-position or proportioning-type valves. Valves controlling modulation shall be equal-percentage proportioning valves. Control valves shall be sized for a 5 psi pressure differential across the valve or a pressure differential of 50 percent of the combined branch piping and coil pressure drop, whichever is greater. Selection of valve sizes shall be based on flow coefficient "C_v" capacities, where "C_v" is defined as the flow of water in gallons per minute divided by the square root of the pressure drop in psi. Control valves shall use either pneumatic, electric, electronic, or self-contained controllers. Valves in cooling and heating systems shall be fail-safe. Valve operators shall be selected to close against pump shutoff head for two-way valves, and one-half pump shut off head for three-way valves.

Setpoints shall be selected to maintain either a fried space temperature or a fixed coil-discharge temperature, with the discharge temperature setpoint reset by space temperature requirements.

1595-7.3 Two-Pipe and Three-Pipe Combination Heating and Cooling Systems

Fan coil terminal devices with one coil shall have their control valves operated by a room or coil discharge temperature thermostat that can change from summer to winter operation. Air handling units with heating and cooling coils shall have their control valves controlled by normal sequences of operation, but shall be provided with two-position control valves in the piping entering each coil to prevent hot water from entering the cooling coil and chilled water from entering the heating coil and to sequence on/off and summer and winter operation.

If the two- or three-pipe water distribution system is not provided with heat exchangers to isolate the boilers and chillers from the distribution system, a control system using three-way control valves to control and route water around the source devices shall be designed to prevent hot water from entering the chiller and cold water from entering the boiler during the changeover periods from heating to cooling seasons.

1595-7.4 Load Control for Hot Water Systems

The temperature of hot water for building heating systems shall be controlled by a supply temperature sensor that modulates the boiler operating controls. The supply delivery temperature shall be reset based on the temperature outside, lowering the delivery temperature as the outdoor air temperature rises and raising the delivery temperature as the outdoor air temperature falls.

1595-7.5 Load Control for Chilled Water Systems

Central station cooling equipment producing chilled water shall be controlled by a signal from a sensor mounted in the return chilled water piping or the leaving chilled water piping that modulates the chiller to control capacity.

Central station cooling equipment shall be provided with controls to limit the current draw of the cooling equipment in periods of high electrical demand.

1595-8 COOLING TOWER AND WATER-COOLED CONDENSER SYSTEM CONTROLS

Cooling tower fans shall be designed with two-speed and on/off controls to reduce power consumption and maintain condenser water temperature. Bypass valve control shall be provided if required to mix cooling tower water with condenser water to maintain the temperature of entering condenser water at the low limit. Condenser water temperature shall be allowed to float to decrease compressor horsepower as long as the temperature remains above a lower limit required by the chiller. Condenser water temperature or flow shall be controlled from condenser head pressure for reciprocating chillers. The design shall provide basin temperature sensing devices and, if the cooling tower is operated during freezing conditions, hot water or steam control valves and additional control system components to maintain cooling tower sump water temperatures above freezing.

1595-9 CONTROL OF STEAM SYSTEMS

1595-9.1 Zone Control

Each zone air handler, heating coil, and individual terminal unit shall be controlled using two-way control valves that actuate either electrically, pneumatically, or through use of self-contained liquid or wax-filled sensing elements. These control valves shall modulate the steam flow to the coil or terminal unit based on space temperature or coil discharge temperature preset by zone temperature requirements.

1595-9.2 Control Valve Selection

Steam pressure and temperature control valves shall be selected according to the requirements in ASHRAE handbooks.

1595-9.3 Load Control for Steam Systems

Intermittent flow controls commonly called “heat timers” shall be evaluated by LCC analysis for incorporation into all space heating steam systems to cycle steam on and off from the source system based on zone indoor temperature requirements, outdoor air temperatures, and space occupancy requirements.

1595-10 ENERGY MANAGEMENT SYSTEMS

Central EMSs shall be provided where justified by LCC analysis. If cost effective, an EMS shall be combined with integral fire and smoke detection supervisory systems and lighting control systems. An EMS shall be specified with the capability to connect to additional building utility systems. When an EMS is contemplated for the future, other building system controls and instrumentation shall be selected that will allow for simple future interfacing.

See Section 0110-12.6, Energy Management Systems.

1595-11 ENERGY METERING

The design professional shall design permanent metering in accordance with 10 CFR 435 for each type of nonprocess energy supplied to and consumed by new buildings and facilities owned and leased by DOE except for the following cases:

- Energy supplied to buildings and facilities where the total energy consumption is not expected to exceed 500 million BTU per year (see Section 0110-12.7, Building Analysis Procedures)
- A type of energy supply that is estimated to be 10 percent or less of the total energy input to the building
- Renewable energy sources or recovered waste heat

Permanent submetering shall be considered and implemented for each type of process energy consumed in new buildings and facilities owned and leased by DOE if indicated in DOE project criteria.

Interface with an existing EMS shall be determined by DOE project criteria.

Division 16
Electrical

1600 GENERAL RETIREMENTS

These criteria are not intended to supercede more stringent or equivalent criteria or standards required for specific facilities or used by any DOE power administration. Planning of systems shall assure that projected requirements will be satisfied.

1605 BASIC ELECTRICAL MATERIALS AND METHODS

1605-1 GENERAL

All systems shall comply with NFPA 70 and ANSI C2. Electrical systems shall be designed so that all components operate within their capacities for initial and projected loads. Preferred standard voltages in conformance with ANSI C84.1 shall be used, with a single-voltage level characteristic in any classification, to minimize stocks of spare equipment and to standardize operating and maintenance practices and procedures.

Electrical materials and equipment shall be UL- or FM-tested, with label attached, for the purpose intended, whenever such products are available. Where there are no UL- or FM-listed products of the type, testing and certification by another nationally recognized testing agency may be acceptable. Installation methods shall be in accordance with the manufacturer's instructions, with NFPA 70, and with other applicable requirements.

On-site acceptance testing shall be required for each major electrical system. Tests shall be specified to demonstrate that each function and important parameter is implemented. Specific criteria shall be included to determine pass/fail acceptance. Tests shall be performed in the presence of a government representative. Copies of all test results shall be submitted for approval.

1605-2 WIRING SYSTEMS

1605-2.1 Raceways

1605-2.1.1 General

Raceways that penetrate fire-rated assemblies shall be noncombustible. The complete installation shall be suitably sealed to maintain the established fire ratings as defined in UL Building Materials Directory and UL 1479. Raceways shall be l/2-inch minimum in diameter. Raceways embedded in concrete or masonry shall be 3/4-inch minimum and shall be adequate in number and capacity for the initial and projected facility requirements.

1605.2.1.2 Electrical Metallic Tubing

EMT shall be used to enclose circuit power conductors, alarm and signal circuits in nonhazardous and noncorrosive locations. It shall not be installed where subjected to physical damages during installation or while in service. EMT shall not be installed underground and shall not be encased in concrete. When EMT is used outdoors or in damp locations, compression type (rain tight) fittings must be used.

1605-2.1.3 Flexible Steel Conduit

Flexible steel conduit shall be used for connection to equipment subject to vibration and connection from junction boxes to recessed lighting fixtures.

1605-2.1.4 Rigid Steel Conduit and Intermediate Metal Conduit

Rigid steel conduit or intermediate metal conduit shall be used in locations classified as hazardous by NFPA 70.

Only rigid steel conduit or intermediate metal conduit shall be used to route secure circuits through nonsecured areas. Such circuits shall be capable of detecting tamper with the line.

1605-2.1.5 Aluminum Conduit

Aluminum conduit shall be used for high-frequency circuits where steel will cause magnetic problems or in atmospheres where steel conduit is unsuitable. Aluminum conduit shall not be used to enclose secure conductors carrying classified information (as defined by the cognizant DOE authority). Aluminum conduit shall not be installed underground, encased in concrete, or where the atmosphere is corrosive to aluminum.

1605-2.1.6 Nonmetallic Conduit

Nonmetallic conduit shall be used only where allowed by NFPA 70. Nonmetallic conduit shall not be used in electromagnetically sensitive areas or to enclose secure conductors, except when required in red/black design in accordance with NSA NACSIM 5203.

1605-2.1.7 Surface-Metal or Nonmetallic Systems

Except for vertical routings to source or termination points, surface-metal or nonmetallic raceways and multi-outlet assemblies shall be used only where allowed by NFPA 70. Surface-metal raceways passing from one floor to another shall have mechanical protection to a height of 4 feet above the floor level.

1605-2.1.8 Cable Trays

The use of cable trays shall be considered for large multiple-cable applications in both interior and exterior locations.

Cable trays that penetrate security barriers shall provide the same degree of penetration resistance as required by the site-specific security plan for the barrier through which they penetrate. This provision applies when the opening at the point the barrier is penetrated is more than 96 square inches in area and over 6 inches in smallest dimension and is located less than:

- Eighteen feet above uncontrolled ground, roofs, or ledges
- Fourteen feet diagonally or directly opposite windows, fire escapes, roofs, or other openings in uncontrolled buildings
- Six feet from uncontrolled openings in the same barrier

1605-2.2 <u>Conductors</u>

1605-2.2.1 General

Conductors for interior electrical systems shall be copper, except that aluminum conductors size No. 4 AWG and larger may be used. Conductors for power and lighting branch circuits shall be not smaller than No. 12 AWG. No. 10 and No. 12 AWG conductors for power and lighting branch circuits shall be solid. No. 8 AWG conductors and larger shall be stranded.

Conductors for Class 1 remote-control and signal circuits shall be enclosed in cable and shall comply with NFPA 70. Conductors for Class 2 low-energy remote-control and signal circuits shall be not smaller than No. 18 AWG. Power and lighting conductors shall be 600-volt, Type THW, XHHW, or THWN. Conductors required to be rated 90 degrees C in accordance with NFPA 70 shall be Type RHH, THW, or THHN. Conductors in high-temperature areas shall be NEC Type FEP or TFE as required. Direct-burial conductors shall be Type UF, UL 493. Bonding and grounding conductors shall be ASTM B1 solid, bare copper for sizes No. 8 AWG and smaller and shall be ASTM B8 Class B stranded copper for wire sizes No. 6 AWG and larger.

Each set of contract documents shall indicate the basis for the size of the conductors shown on those plans when the option for aluminum conductors has been chosen.

1605-2.2.2 Aluminum Conductor Termination

The termination of aluminum conductors, the connection of aluminum terminating lugs to copper or aluminum pads, and the use of Belleville washers shall comply with IEEE 141. Setscrew termination shall be allowed for connection to approved circuit breakers. Split-bolt terminators shall not be used.

1605-2.2.3 Conductor Identification

Voltage levels, grounded conductors, equipment grounding conductors, and ungrounded phase conductors shall be identified.

Existing field center wire color-code systems shall be used. If no present field center wire color code exists, the following color-coding system shall be used:

- Color coding for 240/120-volt, single-phase systems
  - Grounded neutral white
  - Grounding conductor green or bare
  - Ungrounded conductor black
  - Ungrounded conductor red
- Color coding for 208Y/120-volt, three-phase systems
  - Grounded neutral white
  - Grounding conductor green or bare
  - Phase "A" (ungrounded) conductor black
  - Phase "B" (ungrounded) conductor red
  - Phase "C" (ungrounded) conductor blue
- Color coding for 480Y/277-volt, three-phase systems
  - Grounded neutral gray
  - Grounding conductor green or bare
  - Phase "A" (ungrounded) conductor brown
  - Phase "B" (ungrounded) conductor orange
  - Phase "C" (ungrounded) conductor yellow

1605-2.3 Receptacles

Receptacles shall comply with general grade as defined in FS W-C-596.

Receptacle circuits shall be provided with ground-fault circuit-interrupters as directed by NFPA 70.

Receptacle circuits that serve receptacles installed outdoors (except receptacles that are in secure circuits and are not readily accessible) and within 6 feet of sinks and building entrances shall be provided with ground-fault circuit-interrupters.

1620 POWER GENERATION

1620-1 GENERAL

Generally, purchased power from an available off-site utility company shall be used in lieu of central on-site generating stations. Cogeneration shall be considered if steam is being produced for on-site processes or if it is possible to achieve greater economy in power costs. Where an on-site central station is justified, design shall be coordinated with utility company. See Section 1555-1.6, Cogeneration.

1630 EXTERIOR ELECTRICAL UTILITY SERVICE

1630-1 GENERAL

1630-1.1 Load Requirements

Demand and diversity factors shall comply with NFPA 70. Demand and diversity for feeder and substation load calculations shall be as stated in Fink and Beaty, Standard Handbook for Electrical Engineers.

Electric service quality and reliability shall be considered in conformance with IEEE 493 to ensure that they meet the load requirements.

Where loads require a high degree of voltage and frequency stability, the available short-circuit MVA at the service connection and the stability of the supplying utility system shall be considered to ensure adequate power quality.

1630-1.2 Power Factor

An overall power factor of not less than 85 percent shall be achieved. When power-factor correction is required, the amount of correction shall be coordinated with the billing tariff to prevent uneconomical overcorrection. Switched capacitor banks shall be used only when necessary to prevent overvoltages during off-peak hours during low power consumption.

Starting capacitors shall be located as near to the loads as practical. Starting capacitors shall be switched simultaneously with the load.

1630-1.3 Redundancy

Facilities designated by the cognizant DOE authority as critical shall be served by dedicated, redundant circuits. The two services shall be separated by a 4-hour fire-rated barrier and shall be served from separate sources. In lieu of providing two separate services, a single service supplied from a loop-type transmission or distribution system having sectionalizing features may be provided when the reliability of the single service proves adequate when considered in conformance with IEEE 399 and IEEE 493.

1630-1.4 Utility Corridor

Electric circuits shall be located in utility corridors established on master utility plans.

Utility corridors that penetrate security barriers shall provide the same degree of penetration resistance as required by the site-specific security plan for the barrier through which they penetrate. This provision applies when the free area within the utility corridor is more than 96 square inches in area and over 6 inches in smallest dimension.

1630-2 SUPPLY EQUIPMENT AND FACILITIES

1630-2.1 General

Exterior electrical systems shall be designed and constructed with regard to existing electrical system construction in adjacent areas. Design shall be coordinated with the utility company. Relaying shall comply with IEEE 242, and switchgear shall comply to IEEE C37 series.

1630-2.2 Power Supply Lines

1630-2.2.1 General

Circuits shall be arranged so that faults, failures, or maintenance on less critical circuits will not jeopardize critical loads. Protective devices shall be used and coordinated for sequential operation from the load to the source. Line location shall be established in accordance with clearance requirements stated in ANSI C2 and shall be routed within established rights-of-way for each facility. Minimum rights-of-way shall extend 5 feet beyond outside conductors. The cognizant DOE authority shall establish facilities and areas that require additional clearances for security and safety.

1630-2.2.2 Overhead Lines

Overhead power supply lines shall be used where service is to be installed in remote, unsettled, or industrial areas. Maximum use shall be made of single-pole structures.

Joint use of poles for power and communications distribution shall maintain safety standards and shall limit electrical interference to communications services. In the joint usc of poles, either for multiple electrical distribution systems or for both electrical distribution and communications lines, underbuilt lines or cables shall be of vertical construction. Use of double-stacked crossarm construction shall be allowed only where proper clearances for hot-line maintenance work can be ensured. Clearances shall comply with ANSI C2.

1630-2.2.3 Underground Lines

In congested areas and where required for safety, for service continuity, or for conformance with local practices, primary and secondary power distribution circuits shall be placed underground.

Underground distribution circuits may consist of direct-burial cable installations or of cable installed in manholes and duct. Direct-burial cables shall have physical protection where hazards from rodents or soil will impair their safe operation. Underground cables or duct systems shall be suitably identified under the ground surface and above the cable protective system or duct bank.

Direct-burial cable shall be used for secondary (600 volts or below) single-circuit installations through areas not likely to be disturbed by excavation and where service reliability is not of critical importance. Where direct-burial cables are connected to above-grade junction or terminating boxes, they shall be encased in rigid steel conduit from the elevation of the cable to the box.

For primary circuits (above 600 volts) and where secondary circuit service reliability is a prime consideration, cable in duct shall be used. Duct banks shall be concrete-encased. Minimum duct size shall be 2 inches. In seismic zones, ducts may be direct-buried when the risk of loss due to earthquakes is greater than the cost of future utility work adjacent to the circuit. Electric manhole covers shall be appropriately labeled A minimum of 25-percent spare ducts (but not less than two spare ducts) shall be provided in each duct run. Spare ducts shall include nylon or plastic cords of a 200-pound minimum breaking strength to facilitate future cable installation. Spare ducts shall be plugged or capped to prevent contamination.

Underground duct runs that penetrate security barriers shall provide the same degree of penetration resistance as required by the site-specific security plan for the barrier through which they penetrate. This provision applies when the free area within the duct run is more than 96 square inches in area and over six inches in smallest dimension.

1630-2.3 <u>Substations and Switching Stations</u>

1630-2.3.1 General

Design of substations and switching stations shall be coordinated with the utility company. When transformation is their main function, the substations shall be located to optimize the lengths of secondary conductors. When switching is their main function, switching stations shall be located as determined by circuit routings.

1630-2.3.2 Metering

Electric energy (kWh) metering shall be furnished at each substation of 500 kVA or larger capacity. Demand (kW) metering shall be furnished as required for load management purposes.

1630-2.3.3 Grounding

Station grounding shall comply with Section 1639-2, Substation and Switching Station Grounding.

1630-2.3.4 Surge Protection

Surge protection shall be included to limit the potential difference across the terminals of the protected device below the BIL of the device.

1630-2.3.5 Oil-Filled Equipment

Dikes and drainage provisions shall be built as required by the local SPCC in conformance with 40 CFR 112. PCB or PCB-contaminated electrical equipment and the treatment of PCB oil spills shall comply with 40 CFR 761. Oil-filled transformers installed near buildings shall comply with FM 5-4/14-8. Existing PCB or PCB-contaminated equipment shall be provided with warning signs and shall not be relocated or reused in other existing or new facilities. Electrical equipment cooling material shall be handled in accordance with 29 CFR 1910.1200.

1630-3 POWER SUPPLY FOR EXTERIOR LIGHTING

1630-3.1 Primary Power

Where discharge lighting loads are used, the ballasts shall operate at 480 volts when 480Y/277-volt service is available and cost effective.

1630-3.2 Emergency Power

Sites or facilities requiring continuous lighting for safety or security reasons shall have an emergency power source for such lighting.

1630-3.3 Switching

Selective manual/automatic switching systems shall be used to turn off all unnecessary lighting during inactive periods, consistent with safety and security requirements.

1630-4 POWER SUPPLY FOR BUILDINGS

1630-4.1 General

The following factors shall be considered in the selection of power supply for buildings:

- Initial and projected demand for motor, lighting, and power loads and their individual proportions to the total facility load
- Power utilization equipment characteristics
- Power supply options available from existing on-site distribution systems
- Available maximum short-circuit current at the service connection to the facility
- Rate structure of the utility company
- Investment, operating, and maintenance costs of power service options and of the facility's main service equipment

1630-4.2 Voltage Levels

Electric service voltage shall comply with MIL-HDBK-l004/4. For small facilities without three-phase power requirements, 240/120-volt, single-phase service may be used.

1630-5 LIGHTNING PROTECTION

Lightning protection systems shall comply with NFPA 78. Lightning protection systems shall be considered for buildings containing facilities for the use, processing, and storage of radioactive, explosive, and similarly hazardous materials; for buildings over 50 feet in height; and for buildings containing valuable equipment. A risk assessment using the guide in Appendix I of NFPA 78 shall be made of these buildings to determine the risk of loss due to lightning.

Electric power and communication services to all buildings and facilities and to underground power cables, where connected by overhead power distribution lines, shall have lightning and surge protection.

1630-99 SPECIAL FACILITIES

1630-99.8 Telecommunications, Alarm, and ADP Centers and Radio Repeater Stations

Lightning protection shall comply with MIL-HDBK-419. For additional information, refer to FIPS PUB 94.

All electrically grounded towers shall be protected in conformance with NFPA 78. Ground conductors shall be without intervening splices and shall be protected against mechanical damage. Where it is necessary to enclose ground conductors within a tower foundation, separate ground conductors shall be brought to at least two legs of the tower and shall be extended to the air terminal. The point of emergence of ground conductors from the foundation shall be sealed to prevent the entrance of moisture and shall be protected from mechanical damage. Where guy supports are used, ground rods shall be installed at each anchor and connected to all guys terminating at that location. A ground counterpoise system shall be used only when required to meet the needs of the communications system or as necessary to ensure effective grounding.

1639 GROUNDING

1639-1 GENERAL

Grounding systems shall comply with NFPA 70 and IEEE 142. A separate ground conductor shall be used. Raceway systems shall not be used as ground path.

1639-2 SUBSTATION AND SWITCHING STATION GROUNDING

Substation and switching station grounding systems shall comply with IEEE 80. Grounding connections shall comply with IEEE 837.

1639-3 FENCE GROUNDING

Permanent fence grounding shall comply with ANSI C2. Grounding of temporary fences shall depend on the type of fence, consideration of the potential hazards, the expected duration of use and guidance from cognizant DOE safety personnel.

1639-4 ISOLATED GROUND SYSTEMS

Isolated ground systems may be required to meet special instrumentation or other equipment needs. Such ground systems shall be clearly identified, protected against improper usage, and installed in conformance with NFPA 70.

1640 INTERIOR ELECTRICAL SYSTEMS

1640-1 GENERAL

1640-1.1 Demand and Diversity Factors

Demand and diversity factors shall comply with Section 1630-1.1, Load Requirements.

1640-1.2 Power Factor

Interior electrical system power factor shall comply with Section 1630-1.2, Power Factor.

1640-1.3 Interior Distribution Voltage Levels

Standard voltages shall comply with MIL HDBK 1004/4 or shall continue the 240/120-volt single-phase service provided, as applicable.

1640-1.4 Power System Reliability

Power system reliability consideration shall comply with IEEE 493 to ensure continual power supply to systems and equipment designated as critical by the cognizant DOE authority. The need for multiple transformer-switchgear service equipment, to ensure power supply continuity within the facility during scheduled or emergency equipment outages, shall also be considered.

1640-1.5 Power Quality Requirements

Adverse effects of voltage level variations, transients, and frequency variations on equipment operation shall be minimized.

Sensitive electrical equipment, such as data processing equipment, shall be isolated as needed for protection. Uninterruptible power systems, motor-generator sets, or power conditioners may be used for isolation.

1640-1.6 System Protection

System protection shall comply with IEEE 242. For specialized research and development facilities, protection of equipment and systems shall comply with DOE/EV 0051/1.

1640-1.7 Ground-Fault Protection

Ground-fault protection shall comply with NFPA 70. See also Section 1605-2.3, Receptacles.

1640-1.8 Neutral Conductors

The neutral conductor for electric discharge lighting and for data processing and other similar equipment shall be sized in accordance with NFPA 70. Calculations shall include harmonic current.

1640-2 SERVICE EQUIPMENT AND FACILITIES

1640-2.1 General

Interior electrical systems shall comply with NFPA 70. Switchgear criteria shall comply with IEEE C37 series.

1640-2.2 Metering

Energy metering requirements for new buildings and building additions shall comply with Section 1595-11, Energy Metering. Conventional kilowatt-hour meters shall be used for measuring and recording electric energy use at the incoming power service to the building and at the internal service points of significant process loads. Where a facility load management program is used, individually for the facility or as a part of a site load management program, demand (kW) metering shall be used. Metering devices shall be compatible with existing or projected EMSs. See Section 1595-10, Energy Management Systems. Where a facility is to be served directly by a utility company, service metering requirements, equipment to be used, and service metering equipment locations shall be coordinated with the utility company.

1640-2.3 Transformers

Interior service transformer installations shall comply with NFPA 70. The minimum number of transformers necessary to satisfy initial and projected facility loads and operational continuity, safety, and security requirements shall be used. Transformer protection and appurtenances shall comply with IEEE C37.91. Transformer installation shall comply with FM 5-4/14-8.

1640-2.4 Motors

Motors shall comply with NEMA MG-1, except that hermetic refrigerant motor compressors shall comply with UL 984.

Motors shall have a sufficient rating for the duty they are to perform and shall not exceed their continuous horsepower rating, including service factor, when the driven equipment is operating at the greatest horsepower renditions it is likely to encounter. Starting and running characteristics shall be coordinated with the driven machine and the motor control equipment.

Motor enclosures shall be drip-proof for indoor dry locations and totally enclosed or totally enclosed fan-cooled for outdoor or other wet locations, except where special conditions require othewise.

Single-phase motors 1/8 hp and smaller shall be shaded-pole or permanent split capacitor; those larger than 1/8 hp shall be capacitor-start. Polyphase motors shall comply with NEMA Design B, unless other characteristics are required by the driven machine or the speed controller. Motors shall be designed for continuous service at 40°C ambient temperature. Motors shall operate at full capacity, with a voltage variation of plus or minus 10 percent of the nameplate voltage. High-efficiency motors shall be considered where loading and nearly constant usage may result in significant energy savings.

Except where special conditions require otherwise, motors 1 hp and less shall be specified as single-phase, 115-volt motors, while those greater than 1 hp shall be specified as three-phase, 200- or 460-volt, motors.

Motor characteristics shall be selected to avoid excessive acceleration time for motors driving large masses and starting under load.

Variable-speed drives shall be considered where motor speed requirements vary widely during normal operation. Solid-state variable-frequency units are recommended for smaller horsepower motors. In all cases, the driven motor shall be selected in accordance with the drive manufacturer's recommendations to ensure a coordinated system and to avoid overheating the motor.

1640-2.5 Motor Control

Control equipment shall comply with the NEMA ICS standards and UL 508.

All motors shall be provided with fully coordinated control equipment to perform the functions required. Overcurrent devices shall be provided in each ungrounded conductor; overcurrent devices located in the motor or controller shall be rated in accordance with the manufacturer's instructions. Manually reset devices are recommended.

Single-phase motors may be controlled directly by automatic control devices of adequate rating. Polyphase motors controlled automatically and all polyphase motors rated greater than 1 hp shall have magnetic starters.

Control devices shall be of adequate voltage and current rating for the duty to be performed. Pilot control circuits shall operate with one side grounded, at no greater than 120 volts. Where control power transformers arc required, they shall be located inside the associated motor starter housing, shall be protected against faults and overload by properly sized overcurrent devices, and shall be of sufficient capacity to serve all devices connected to them without overload.

Reduced-voltage starters shall be provided for larger motors where starting the motor may result in unacceptable voltage dip.

1640-3 POWER SERVICE FOR SECURITY, COMMUNICATIONS, AND ALARM SYSTEMS

1640-3.1 General

Electric power distribution systems shall be filtered to reduce emanation of detectable electromagnetic signals to acceptable levels as directed by the cognizant DOE telecommunications and security personnel. Installations shall comply with DOE 5300.2B, DOE 5300.3B, and DOE 5300.4B. Additional guidance shall be obtained from the Office of Computer Services and Telecommunications Management, DOE Headquarters, as directed by the cognizant DOE authority.

1640-3.2 Primary Power Supply

Normal primary power for protective alarm and communications systems shall come directly from the on-site power distribution system or, in the case of isolated facilities, shall come directly from the public utility. Where several primary power sources are available, the most reliable source shall be used.

1640-3.3 Standby or Emergency Power Supplies

Standby or emergency power supplies for security, communications, and alarm systems shall be provided in accordance with Section 1660, Special Systems.

1640-99 SPECIAL FACILITIES

1640-99.2 Emergency Preparedness Facilities

Electrical distribution systems shall ensure the needed degree of flexibility for facility work and for personnel safety. Special-purpose receptacles shall be marked as to voltage, amperage, number of phases, power source, conventional building power or conditioned power, AC or DC, and frequency. Emergency preparedness facilities shall have emergency power provisions according to Section 1660, Special Systems.

1640-99.7 Occupational Health Facilities

Electrical design of occupational health facilities shall comply with NFPA 99 and IEEE 602.

1640-99.8 Telecommunications, Alarm, and ADP Centers and Radio Repeater Stations

1640-99.8.1 General

Essential equipment shall be connected to uninterruptible power supply or to emergency power. Design shall be coordinated with the equipment system specialists and DOE security personnel. Where continuity of service is required for critical cord-connected equipment, twist-lock-type connectors shall be used.

1640-99.8.2 ADP Centers

Emergency shutdown of power for ADP facilities shall comply with DOE/EP 0108 and NFPA 75. See FIPS PUB 94 for additional information.

1640-99.8.3 Radio Control Centers

In determining the power supply requirements, it shall be assumed that all transmitters are keyed simultaneously while associated receivers and other equipment and building services are in operation.

1650 EXTERIOR LIGHTING

1650-1 GENERAL

Exterior lighting systems shall comply with IES Lighting handbook. System control shall use time clock and/or photocell to provide illumination only when needed.

Light glare shall be kept to a minimum in those situations where it would impede effective operations of protective force personnel, interfere with rail, highway, or navigable water traffic, or be objectionable to occupants of adjacent properties.

For protective lighting, see Section 0283-7, Lighting.

1656-2 LIGHTING SOURCES

Maximum use shall be made of high-efficiency HID lamps such as metal halide or high-pressure sodium vapor lamps.

HID lamps shall not be used for exterior lighting within 25 miles of observatories.

See Section 0283-7, Lighting, for use of HID lamps for protective lighting.

1655 INTERIOR LIGHTING

1655-1 GENERAL

Interior lighting systems shall comply with the IES Lighting handbook. Nonuniform lighting practices shall comply with 41 CFR 101-20.116-2 and with Section 1694, Energy Conservation. Lighting power budget shall be determined in conformance with ASHRAE Standard 90. Exit and emergency lighting systems shall comply with NFPA 101 and NFPA 110.

1655-2 LIGHTING SOURCES

Maximum use shall be made of fluorescent and HID lamps. Where HID lamps are used, a standby lighting system shall be provided to meet emergency lighting requirements during HID lamp restrike periods. When using HID lighting indoors, careful consideration of the required color rendition shall be made from visual and health safety perspectives.

1655-3 FIXTURES

Fixtures shall have diffusers and lenses constructed of noncombustible materials.

1655-99 SPECIAL FACILITIES

1655-99.8 Telecommunications, Alarm, and ADP Centers and Radio Repeater Stations

Lighting fixture types, location, and illumination levels shall be coordinated with the equipment and functions of telecommunication, alarm, and ADP centers to provide the required illumination without:

- Interfering with prompt identification of self-illuminate indicating devices
- Creating reflecting glare that might detract from adequate observation of essential equipment
- Creating electrical or electromagnetic interference detrimental to proper operation of equipment

1660 SPECIAL SYSTEMS

1660-1 GENERAL

Standby and emergency systems shall serve loads set forth in NFPA 110. Additional standby or emergency systems shall be provided to support systems or equipment components whose operating continuity is determined to be vital by the cognizant DOE authorities for protection of health, life, property, and safeguards and security systems. Safety Class 1 items shall be provided with emergency power.

Optional standby systems shall be provided for production process operations in cases where the cognizant DOE authority determines that the process will become unstable on loss of power or that a severe monetary loss will result.

Uninterruptible power shall be provided for equipment that cannot sustain functions through the momentary power loss that occurs when an alternate power source comes on line and picks up the load. See Section 1660-3, Uninterruptible Power Systems.

Emergency power shall be provided for protective alarm and communications systems as dictated by the system requirements. Switchover to emergency power shall be automatic on failure of the primary power source and shall be indicated on an annunciator panel. The annunciator shall be located in an occupied area and shall indicate any problems with the emergency system. Definition of "emergency systems" "legally required standby systems," and "optional standby systems" shall be in accordance with NFPA 70.

Emergency power equipment areas shall be ventilated to exhaust hazardous gases (if applicable) and to maintain satisfactory ambient temperatures for equipment operation or personnel access.

Emergency or standby power shall service fire alarm, security alarm, and supervisory sensing devices designated essential by the cognizant DOE authority.

Emergency power systems are further detailed in Section 1660-99, Special Facilities.

1660-2 EMERGENCY POWER SYSTEMS

Emergency power systems shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110, and IEEE 446.

Emergency power systems shall be capable of maintaining full operation of emergency loads for the full time period specified by the cognizant DOE authority (nominally, a minimum of 24 hours). Such power sources shall have the necessary built-in features to facilitate operational testing on a periodic basis to verify their readiness.

Where emergency generators are required for loads 25 kVA and smaller, gasoline or LPG engines may be used. For loads greater than 25 kVA, diesel engines shall generally be used. Steam-turbine generators may be used if steam is being produced for on-site processes. Gas turbines may be used if an LCC analysis warrants and if the NEC criteria to emergency power throw-over time is met.

Application of diesel engines shall comply with FCC Technical Report No. 69.

Batteries, when required, shall be rechargeable and shall be kept fully charged at all times when primary power is available. The charger shall automatically switch from float to fast charge rate at a preset drop in DC bus voltage. The charger shall be furnished with a capacity to charge the battery from a fully discharged state to not less than 85 percent of the rated ampere-hour capacity within 24 to 72 hours. See also IEEE 308.

Emergency power systems legally required by NFPA 70 shall be installed to meet normal emergency power requirements. More stringent emergency power requirements shall be identified by the cognizant DOE authority on a case-by-case basis.

1660-3 UNINTERRUPTIBLE POWER SYSTEMS

Uninterruptible power supplies shall be provided for those loads requiring guaranteed continuous power. Application of UPSs shall comply with IEEE 446, as modified by the cognizant DOE authority. UPS installations may be Safety Class 1 (Seismic Category I functional) or standby type dependent on the classification of the loads served.

1660-99 SPECIAL FACILITIES

1660-99.0 <u>Nonreactor Nuclear Facilities-General</u>

1660-99.0.1 Safety Class (Emergency) Electrical Systems

Electric power and electrical instrumentation and control systems are designated safety class electric if they are required to satisfy the safety class criteria in Section 1300-3.1, General, through Section 1300-3.4, Equipment Environment Considerations. These components and systems are subject to the basic approach outlined in the IEEE 308 standards and to higher quality assurance requirements as needed.

For safety class items that require electric power to perform their safety functions, the design shall provide safety class emergency electric power systems (AC, DC, and their distribution systems). The design shall define the type, capacity, performance characteristics, and features of the safety class electric systems, including generator and batteries, required to meet safety class system needs.

Safety class electric systems shall be provided with suitable redundancy and separation to ensure that adequate capacity and capability are available with the addition of a single failure.

Redundant safety class electric systems shall be physically protected or separated to prevent a common external event from causing a failure of the redundant systems. IEEE 379 and IEEE 384 shall be used as redundancy and separation criteria.

The connection of loads that do not require safety class power to safety class buses shall be minimized. Where such loads must be connected to a safety class electric power system, the loads shall be provided with suitable separation or devices that will prevent failures from affecting the safety class electric system.

Safety class electric systems shall be qualified to the requirements in Section 1300-3.4, Equipment Environment Considerations, and, as appropriate, to the structural requirements imposed on safety class items in Section 0111-99, Special Facilities.

Testing or a combination of testing and analysis shall be the preferred method of demonstrating the operability of instrumentation and electrical equipment that are required to operate during and following a DBE. Seismic experience data may be used as an alternative to testing or dynamic analysis where such data have been documented and validated.

The capability to periodically test safety class electric systems to verify system performance shall be provided.

1660-99.0.2 Protection System and Instrumentation and Controls

The design shall provide, as necessary, safety class protection systems and safety class instrumentation and control systems to minimize the risk associated with facility operation.

Protection Systems

A protection system is a system that initiates corrective action, eg., fire detection/Halon release, UPS.

The protection system shall provide automatic initiation of protective actions that require rapid response and automatic control of interlocks that prevent unsafe operator actions.

Protection systems shall be designed to sense potentially hazardous conditions and to initiate actions to ensure that specific acceptable design limits are not exceeded as a result of anticipated operational occurrences.

The protection system shall automatically activate safety class systems and components that are required to ensure the safety of operating personnel and the public. It shall provide audible and visual indication of system status, Automatically initiated protective actions shall be provided with a manually initiated backup.

The design of the protection system shall provide suitable redundancy and diversity to ensure that safety functions can be completed, when required, and that no single failure will result in the loss of the protective functions. The protection system shall be designed to fail in a safe state following a component or channel failure or loss of power (e.g., control air or electric power).

Safety Class Instrumentation and Controls

Safety class instrumentation shall sense abnormal conditions affecting safety and subsequently provide an alarm, e.g., low differential pressure between HVAC zones, criticality monitoring.

Safety class instrumentation and control systems shall provide audible and visual alarms so that the operator can take timely corrective actions to ensure the safety of operating personnel and the public.

The safety class instrumentation shall be designed to monitor safety-related variables and safety class systems over expected ranges for normal operation, anticipated operational occurrences, DBA conditions, and for safe shutdown. Safety class controls shall be provided when they are necessary to control these variables. Typical systems whose design shall require safety class instrumentation and controls include safety-related process systems, safety class confinement systems, and safety class cooling systems.

The design of safety class instrumentation and controls shall provide suitable redundancy and diversity to ensure that safety functions can be completed, when required, and that no single failure will result in the loss of the protective functions. The safety class instrumentation and controls shall fail in a safe state following a component or channel failure or loss of power (e.g., control air, electric power).

1660-99.0.3 Qualification

Protection systems and safety class instrumentation and control equipment shall be qualified to the environmental qualification requirements in Section 1303.4, Equipment Environment Considerations.

1640-99.0.4 Separation and Physical Protection

Redundant protection system and safety class instrument channels shall be physically protected or separated to prevent a common external event or failure of one channel from causing a failure in the redundant channel.

The safety class protection system and safety class instrumentation and control system shall be appropriately separated or isolated from other instrumentation and control systems to the extent that a failure (e.g., electrical, control air) in these other systems will not degrade the safety class systems to the extent that they are unable to perform their necessary safety functions.

1660-99.0.5 Test and Calibration

The design of protection system and safety class instrumentation and control systems shall provide for the periodic in-place testing and calibration of instrument channels and interlocks. The design shall allow periodic testing of protective functions to determine whether failure or loss of redundancy may have occurred.

1660-99.0.6 Power sources

An analysis shall be made to determine power requirements for safe shutdown of the process. Safety class electric power or a safety class control air system shall be provided unless adequate system performance including fail-safe shutdown can be demonstrated when only the conventional power sources are used.

1660-99.0.7 Control Areas

Control areas or a control room shall be designed to allow occupancy and actions to be taken to operate the facility safely under normal conditions, anticipated operational occurrences, and DBA conditions to achieve and maintain a safe shutdown condition including the remote manual initiation and control of safety functions, if used. In the event that a control area or control room is disabled, there shall be sufficient redundancy and capability to allow the facility to be placed in a safe shutdown condition.

1660-99.4 Explosives Facilities

1660-99.4.1 General

The NEC and this section are the minimum electrical requirements for DOE facilities containing explosives.

1660-99.4.2 Electrical Equipment and Wiring

All permanent equipment and wiring for those areas containing explosives shall conform to the standards of the NEC hazardous locations Class II or Class I and II (dual rated). For Class II installations, provisions should be made for easy conversion to Class I. The NEC does not specifically address explosives; however, Article 500, Hazardous (Classified) Locations," establishes requirements for the design and installation of electrical equipment and wiring in locations containing combustible dusts and flammable liquids, vapors, or gases that, in general, are comparably hazardous. Exceptions for laboratory operations are discussed in DOE/EV 06194.

Hazardous Locations

NEC definitions of Class I and II hazardous locations are modified as follows for DOE explosives facilities applications.

- Areas containing explosives dusts or explosives that “may, through handling or proccssing, produce dust capable of being dispersed in the atmosphere shall be regarded as Class II, Division 1, hazardous locations.

- Areas that contain exposed explosives but where no dust hazard exists may be regarded as Class II, Division 2, hazardous locations.

- Areas where explosives are processed and sublimation may occur or where flammable gases or vapors may be present in sufficient quantities to produce explosive or ignitable mixtures shall be regarded as Class I, Division 1.

Watertight equipment (that which would pass a NEMA 4 hose test) should be provided in those locations where water-explosives mixtures may come in contact with the electrical equipment and wiring.

If the properties of an explosive are such that Class II, Group G, equipment provides inadequate surface temperature limits, special protection shall be provided, or the equipment shall be excluded from the hazardous location. This equipment shall not have a surface temperature exceeding the lowest onset of the exotherm of the explosive, as determined by the DTA test or the DSC test (see DOE/EV 06194).

When NEC Class I or II equipment is not available, the substitute equipment should either be purged (in accordance with NFPA 496), be sealed to prevent explosives contamination, be determined intrinsically safe by facility management, or be administratively controlled. If equipment is purged, it must be monitored for flow.

Areas containing explosives that are not defined as hazardous locations (areas containing no dust, vapor, or gas hazards or exposed explosives, e.g., storage magazines) shall be evaluated and documented to ensure that electrical ignition sources are minimized, or shall be regarded as NEC Class II.

Electrical Supply Systems

Mutual hazards may exist where explosives facilities are located near electrical supply lines. To protect against these hazards, ANSI C2 and the following requirements shall apply to all new construction or major modifications, and shall be considered for existing facilities:

- Electric lines serving explosives facilities shall be installed underground from a point not less than 50 feet away from such facilities. This also applies to communications and instrumentation lines and security alarm systems.

- Electric service lines required to be in close proximity to an explosives facility shall be no closer to that facility than the length of the lines between the poles or towers supporting the lines, unless an effective means is provided to ensure that broken, energized lines cannot come into contact with, and present a hazard to, the facility or its appurtenances.

- Unmanned electrical substations shall be no closer to explosives facilities than public traffic route distances (as defined in DOD 6055.9)

- Electrical transmission lines (carrying 69 kV or more) and the tower or poles supporting them shall be located no closer to explosives than:

- Inhabited building distance if the line in question is part of a system serving a large, off-site area

- Public traffic route distance if loss of the line will not create serious social or economic hardships

Underground utility separation distance criteria are found in Table 1660-99.4.2. Permanent DOE-controlled underground utilities installations (excluding building service lines) shall be separated from explosives locations containing Class 1.1 materials (defined in DOE/EV 06194) according to Table 1660-99.4.2. Utilities installations (above-ground and underground)

Table 1660-99.4.2 Quantity-Distance Separation For Protection of Underground Service Installations

	Quantity of Explosives (maximum pounds)				
	0-10,000	20,000	50,000	100,000	250,000
Distance					
Meters	26	28	36	46	62
Feet	80	85	110	140	190

Note: If the explosives building is designed to contain the effects of an explosion, the formula $D = 3.0 W^{1/3}$ where D is distance in feet and W is the weight of explosives in pounds can be used to determine separation distances for less than 20,000 pounds.

that are privatety owned or operated shall be separated from explosives locations by at least public traffic route distances. If these installations include structures they shall be sepamted from explosives facilities by the inhabited building distances.

Building Service Entrance

Electrical service entrance for explosives facilities shall be provided with:

- An intermediate, valve-type lightning arrester on the primary side of the transformer
- Surge arresters and surge capacitors on the supply side of the main service disconnect
- Interconnected grounding between the lightning arrestor, surge arrestor, surge capacitors, service entrance ground, and building ground

1660-99.4.3 Static Electricity

General

Positive steps shall be taken control or eliminate static electricity in areas where materials that are ignitable by static spark discharge are processed or handled. This includes spark-sensitive explosives, propellants, and pyrotechnics as well as solvent vapors and flammable gases.

Bonding and Grounding of Equipment

Bonding straps shall be used to bridge locations where electrical continuity may be broken by the presence of oil on bearings, paint, or rust at any contact point. Permanent equipment in contact with conductive floors or table tops is not considered to be adequately grounded. Static grounds shall not be made to gas, steam, or air lines, dry pipe sprinkler systems, or air terminals of lightning protection systems. If a structure is equipped with lightning protection system, all grounds must be interconnected. Wires used as static ground conductors should be at least No. 10 AWG.

Conductive Floor Specifications

Conductive floors shall be made of non-sparking material such as lead, conductive rubber, or conductive flooring composition and shall meet the following requirements:

- The flooring and its grounding system shall provide for electrical resistance not to exceed 1 million ohms. he resistance is to be measured as prescribed in DOE/EV 06194.
- The surface of the installed floor shall be free from cracks and reasonably smooth. The material must not slough off, wrinkle, or buckle under operating conditions.
- Conductive floors shall be compatible with the explosive materials to be processed.

Ground Fault Circuit Interrupter

Ground fault circuit interrupter protection shall be provided in static grounded areas where personnel may come in contact with AC-powered electrical equipment.

1660-99.4.4 Lightning Protection

Lightning protection shall be provided for buildings containing explosives as determined by an assessment of need for lightning protection conducted using the criteria in this division, DOE/EV 06194, and NFPA 78, Appendix I. Specific explosives operations shall also be assessed for the risk of initiation of process material by lightning. Lightning protection is required for facilities where operations are conducted with electrostatic-sensitive explosive material or components. Installation of protection systems shall be in accordance with the requirements of NFPA 78 or project-specific criteria provided by the cognizant DOE authority.

1670 EXTERIOR COMMUNICATIONS AND ALARM SYSTEMS

1670-1 GENERAL

Systems shall be designed to avoid unnecessary duplication of facilities. Emergency power supply facilities, exterior power supply pole lines, and underground power supply duct bank systems shall be used jointly for the installation unless the joint use of facilities will degrade system performance. Joint use shall not expose the security system to damage or to unauthorized access. Power wiring and signal wiring shall not share the same conduit.

The following shall be considered in the design of telecommunications and alarm facilities:

- Areas and locations to be served
- Initial and ultimate requirements for telecommunications and alarm services
- Type of construction to be used

1670-2 FIRE ALARM AND SUPERVISORY SYSTEMS

Fire alarm and supervisory systems shall comply with NFPA 71, NFPA 72A, NFPA 72B, NFPA 72C, NFPA 72D, NFPA 72E, NFPA 72F, NFPA 72G, NFPA 72H, NFPA 1221, and ANSI C2 as appropriate for the location. Outside cable plant for fire alarm and supervisory systems shall comply with the standards for telephone cable plant. In the joint use of poles for electric power distribution and for supporting fire alarm and telephone cables, separate fire alarm cable shall be placed below the telephone cable.

Fire alarm cables installed in underground ducts shall be distinctively marked within manholes and handholes that are shared with other communications cables and shall be kept physically separated from all power conductors.

Exterior fire alarm pull boxes and emergency-reporting telephones shall be installed in weatherproof housings manufactured specifically for the mechanism.

1670-3 SECURITY ALARM AND ASSESSMENT SYSTEMS

Devices and equipment for interior IDSs required for SNM and storage of classified matter shall meet FS W-A-450B or equipment as approved by the cognizant DOE authority.

Purchases of new protective alarm equipment or replacement of existing equipment shall be approved by the cognizant DOE authority.

Protective alarm systems shall have a primary and emergency power source.

Emergency power for protective alarm systems shall be supplied by batteries or engine-driven generators. Switchover to the emergency power shall be automatic on failure of the primary power source, and on failure of both the primary and emergency power sources a signal shall be generated to indicate an alarm condition at the monitor.

Rechargeable batteries shall be kept fully charged or subject to automatic recharging whenever the voltage drops to a level specified by the battery manufacturer. Nonrechargeable batteries shall be replaced whenever the voltage drops 20 percent below the rated voltage; a signal shall be activated in the monitor to indicate when this condition exists.

Auxiliary power sources shall be capable of maintaining full operation of the alarm system for not less than 8 hours. As determined by the cognizant DOE authority, such power sources shall contain a switching capability to facilitate operational testing to determine adequate emergency power sources. Such power sources shall be maintained by qualified service personnel.

The power supply, other than public utility, shall be vented sufficiently to preclude deterioration of any of its components as a result of operation under high temperatures.

Supervisory and line-tamper circuits for existing alarm systems that protect Category I or II amounts of SNM shall meet the following requirements:

- Direct or alternating current with continuous line supervision adequate to detect a short, open, or substitution shall be the minimum used, provided that all equipment containers, junction boxes, and so forth, are tamper resistant and that alarm wiring is contained in rigid wall metal conduit. Digital line supervision is preferred over direct or alternating current supervision.

- The system shall be capable of detecting tamper with the system, any component, or the line in both the secure and access modes.

- Interface components such as line moderns or data-gathering panels shall be located, if practical, either at the central annunciating point or in the protected area. All components located in the field (eg., line amplifiers) shall be tamper protected and preferably buried or located within a building.

- If dedicated telephone cable pairs are used to connect the protected area to the annunciating point, they must not be routed through telephone switching equipment. Where connected through frame rooms, the pairs shall not be identified as alarm system pairs.

Supervisory and line-tamper circuits for new alarm systems that protect Category I or II amounts of SNM shall meet the following requirements:

- A continuously polled, digital interrogation/response transmission system shall be used.

- Each protected zone shall have a unique digital address code.

- The polling shall be in a pseudo-random manner (i.e., all zones are polled during each sequence but the order or start point is varied). Alternately, encryption may be used.

- Interface components such as line modems or data-gathering panels shall be located, if practical, either at the central annunciating point or in the protected area. All components located in the field (eg., line amplifiers) shall be tamper protected and preferably buried or located within a building.

  The interface equipment shall be capable of initiating an alarm if any malfunction or tamper occurs while in both the access or secure modes.

- The polling sequence shall poll all protected zones at the fastest rate consistent with the type of transmission media used (e.g., coaxial cable, radio, or telephone pairs).

- A redundant and separately located transmission line shall be installed. If two cables are used, they shall not be installed in the same trench.

1670-4 SECURE COMMUNICATIONS SYSTEMS

Secure communications systems shall comply with DOE 5300.3B, DOE 5300.4B, and the DOE 5632 series.

Data processing, amplifying, telecommunications, and other systems that emit electromagnetic emanations, and communications lines to remote interrogation points used to process classified data processing information, shall be protected against compromise of such data in accordance with DOE 5637.1, DOE 5300.2B, and DOE 5300.4B.

For the protection of classified matter, line supervision limits and/or line tamper alarm capability shall meet UL Class AA requirements.

Telephones or public address systems in conference rooms or offices in which classified discussions at the Secret or Top Secret level occur shall comply with Section 0110-99.10, Secure Conference Rooms, and Section 0110-99.11, Secure Offices, respectively.

Where transmissions of classified data outside security areas are involved, NSA-approved encryption shall be used or the signal lines shall be installed in accordance with DOE. 5300.4B.

ADP equipment and cabling shall be installed per NSA NACSIM 5203 or other means approved by the CSOM to preclude compromising emanations from radiating beyond the control zone.

1670.5 ENERGY MANAGEMENT SYSTEMS AND DEVICES

When directed by the cognizant DOE authority, EMSs and their accessories shall be included in the design of new or upgraded telecommunications and alarm systems.

1670-6 ANTENNA TOWERS, POLES, AND MASTS

Antennas or reflectors, transmission lines, and other equipment to be mounted on the antenna structures, and the location, number, height, arrangement, and orientation of antenna structures shall comply with DOE 5300.1B and guidance from the Headquarters Office of Computer Services and Telecommunications Management.

Reference drawings and specifications obtained from Headquarters Office of Computer Services and Telecommunications Management may be used as guidance for the following

- Typical antenna mast suitable for supporting various types of VHF or UHF and with mounting details

- Underground, hardened, and remotely controlled telescoping pushup antenna structures and facilities for HF applications

1671 INTERIOR COMMUNICATIONS AND ALARM SYSTEMS

1671-1 PLANNING

1671-1.1 General

Specific project communications requirements shall be designated by the cognizant DOE authority.

Interior communications and alarm systems shall be designed to use standard, commercially available equipment. The initial and projected requirements for telecommunications systems shall comply with DOE 5300.1B. Secure communications systems shall comply with DOE 5300.3B. TEMPEST criteria shall be as set forth in DOE 5300.2B. Protected distribution systems shall comply with DOE 5300.4B. Data communications facilities, services, and equipment shall comply with DOE 5300.1B. Spectrum-dependent services shall comply with DOE 5300.1B. See also Section 0110-1.2, Systems Integration.

1671-1.2 Joint Use

Telephone circuits shall be used for other telecommunications and alarm services to the maximum extent practicable. If separate conductors are required, they shall be routed through the main telecommunications and signal raceway systems if raceway systems are present. Separate wireways and cabinets shall be used only when necessary to meet security, technical, or code requirements or to achieve significant economies.

1671-1.3 Hazardous Locations

Telecommunications and alarm equipment and conductors shall be located outside areas subject to explosion, fire, flood, chemical fumes, excessive dust, radiation or vibration, and excessive electrical or electromagnetic noise levels. Where telecommunications and alarm services must be extended into these areas, equipment and installation shall be suitable for the hazard.

1671-1.4 Security Conference Rooms and Security Offices

See Section 0110-99.10.1, General, and Section 0110-99.11.1, General.

1671-2 FIRE ALARM AND SUPERVISORY SYSTEMS

Fire alarm and signaling systems shall comply with NFPA 72A, NFPA 72B, NFPA 72C, NFPA 72D, NFPA 72E, NFPA 72F, NFPA 72G, and NFPA 72H.

1685 ELECTRIC SPACE HEATING

Electric space heating may be considered where economically justified by LCC analysis.

1694 ENERGY CONSERVATION

1694-1 GENERAL

System planning and equipment selection shall maximize efficient energy usage and shall minimize energy losses within the electrical system on an LCC-effective basis. See Section 0110-12, Energy Conservation, for criteria on LCC for energy conservation. Industrial systems shall comply with IEEE 739. Commercial systems shall comply with ASHRAE Standard 90.

1694-2 ENERGY MANAGEMENT SYSTEMS AND DEVICES

In the planning and design of new systems and for alterations or additions to existing systems, the need for and potential benefits from EMSs and devices as a part of, expansion of, or in addition to such systems shall be considered. See Section 1595, Controls.

Key Word Index

Absorption refrigeration 15-32

Access 5, 14, 15, 16, 18, 20, 21, 22, 23, 26, 1-6, 1-30, 1-47, 1-53, 1-57, 1-61, 1-68-74, 1-76, 1-78-81, 1-83-86, 1-103, 1-106, 2-5, 2-7, 2-8, 2-25-27, 2-42, 2-44, 2-53-55, 2-57, 2-58, 2-60, 2-61, 2-65, 2-67, 7-10, 8-1, 8-2, 9-5, 9-6, 10-2, 11-3, 13-5, 13-9, 13-10, 13-13, 13-17-25, 13-27-29, 13-32, 13-33, 13-37, 13-39, 13-40, 13-43, 13-51, 13-53-55, 13-59, 13-60, 13-67, 13- 74, 13-79, 13-89, 13-90, 13-95, 13-109, 13-110, 13-114, 14-2, 14-3, 15-19, 15-42, 15-44, 15-49, 15-53, 15-69, 15-74, 16-16, 16-24-26

Access area 5, 20, 23, 1-68-70, 1-74, 2-53, 13-18, 13-20, 13-22, 13-23, 13-27, 13-53, 13-59, 13-79, 13-95

Access control 21, 23, 26, 1-68, 1-80, 1-84-86, 2-7, 2-54, 13-18-23, 13-25, 13-28, 13-67, 14-2

Access drive 2-27

Access flooring 1-53, 10-2

Access road 1-103, 1-106, 2-67

Access way 13-10, 13-13, 13-54, 13-60, 13-89, 13-109

Accessibility 8, 1-6, 1-9, 1-57, 1-77, 2-29, 2-68, 11-2, 13-37, 13-40, 13-44, 15-69

Accident 3, 6, 9, 11, 12, 13, 15, 16, 21, 22, 1-17, 1-35, 1-53, 1-54, 1-76, 1-97, 1-100, 1-107, 2-1-3, 2-6, 13-3, 13-4, 13-6-8, 13-11, 13-12, 13-44, 13-52, 13-57, 13-60, 13-64, 13-67, 13-69, 13-70, 13-76, 13-82, 13-86, 13-92, 13-97, 13-100, 13- 105, 13-112, 13-116-120, 13-122-125, 15-11, 15-13, 15-20, 15-45, 15-50

Accidental release 13-4, 13-7, 13-12, 13-50, 13-55, 13-57, 13-61, 13-64, 13-68, 13-84, 13-90, 13-102, 13-110, 13-111, 13-115, 13-125, 15-3, 15-45, 15-50

Acoustic 1-81, 9-5, 13-38

Acoustic plaster 9-5

Acrylonitrile-butadiene-styrene (ABS) 1, 15-17

Action description memorandum (ADM) 1, 1-104

Active solar 1-61, 1-67

Actuating device 15-9

Adiabatic 15-25, 15-27, 15-28

Adsorption 13-73, 13-95, 13-123

Adversary 1-69, 1-70, 2-31, 2-61, 2-62, 13-16, 13-17, 13-19, 13-21, 13-24-27

Aesthetic 2-2, 2-44, 2-64, 13-39, 15-73

Agitation 13-30, 13-94, 13-102

Air cleaning 1-22, 1-28, 13-51, 13-80, 15-29, 15-38, 15-48, 15-75

Air compressor 2-23, 15-77

Air conditioning 7, 1-19, 1-40, 1-46, 13-27

Air distribution 1-13, 1-72, 15-28-30, 15-37, 15-41, 15-42, 15-52

Air filtration 13-34, 13-84, 15-45, 15-53, 15-79

Air handling unit (AHU) 1, 1-19, 15-28-31, 15-37, 15-39, 15-41, 15-43, 15-78-81

Air leakage 1-60, 1-61, 15-77

Air lock 1-57, 13-13, 13-49, 13-55, 13-90, 13-110, 15-44

Air monitoring 2, 13-10, 15-52

Air pollution 1-31, 1-57, 1-105, 13-14, 13-16, 15-55, 15-71, 15-72, 15-75

Air quality 1-21, 1-60, 1-105, 2-1, 2-4, 2-45, 9-1, 15-28, 15-29, 15-40, 15-73, 15-74

Air retarder 7-6

Air vaporizer 15-65

Airborne 14, 1-18, 1-105, 11-1, 13-10, 13-13-15, 13-39, 13-47, 13-50, 13-57, 13-62, 13-75, 13-78, 13-80-82, 13-84, 13-85, 13-87, 13-89, 13-91, 13-96, 13-97, 13- 102, 13-104, 13-111, 13-116, 13-121, 13-126, 15-44, 15-47, 15-48, 15-50, 15-52, 15-53, 15-71, 15-76

Airborne effluent 13-14, 13-50, 13-57, 13-62, 13-75, 13-81, 13-85, 13-91, 13-96, 13-97, 13-104, 13-111, 13-116, 13-121, 13-126, 15-76

Aircraft 10, 1-30, 1-40, 1-100, 2-28-30, 13-21

Airfield 2-28-30

Double-hyphen entries indicate inclusive pages, e.g., “3-27-29” means page 3-27 through page 3-29. Entries for singular words can include plurals.

Alarm 2, 4, 7, 12, 13, 19, 29, 1-5, 1-17, 1-32, 1-39, 1-48, 1-52, 1-57, 1-68-70, 1-73, 1-75, 1-76, 1-78-80, 1-84-87, 2-7, 2-8, 2-17, 2-50, 2-52, 2-53, 2-58, 2-61, 8-7, 11-4, 13-2, 13-7-11, 13-18-20, 13-22-25, 13-28, 13-29, 13-34, 13-41, 13-42, 13-53, 13-59, 13-63, 13-74, 13-80, 13-90, 13-96, 13-114, 13- 117, 13-123, 14-1, 14-2, 15-4, 15-6, 15-8, 15-9, 15-11-14, 15-44-46, 15-49, 15-52, 15-53, 15-70, 15-73, 16-2, 16-9, 16-13-16, 16-19, 16-21, 16-24-28

Alarm readout 13-11

Allowable soil-bearing capacity 9

Alternating current (AC) 1, (AC) 1-30, (AC) 2-28-30, 16-14, 16-18, 16-23, 16-25

Alternative designs 1-52, 2-21

Alternative production 2-47

Alternative technology 2-67

Aluminum 1, 1-13, 1-14, 1-24, 1-46, 5-1, 5-3, 7-13, 8-3, 8-4, 8-6, 9-7, 15-41, 15-66-68, 16-2-4

Ambient 9, 22, 13-11, 13-104, 15-1, 15-9, 15-28, 15-30, 15-53, 15-65, 15-68, 16-12, 16-16

Anaerobic digestion 9

Anchor bolt 4-2

Annunciating equipment 1-85

Annunciation 1-79, 13-24, 15-8

Annunciator 1-79, 13-24, 13-41, 15-14, 16-16

Antenna 1-28, 1-78, 1-84, 1-86, 5-2, 16-27

Anticipated Operational Occurrence 9, 1-73, 13-3, 13-5, 13-12, 13-15, 13-47-49, 13-52-55, 13-58-61, 13-74, 13-79, 13-80, 13- 84, 13-87-90, 13-95, 13-96, 13-101, 13-102, 13-105, 13-107, 13-109, 13-110, 13-113, 13-114, 13-118, 13-119, 13-124, 13-125, 13-127, 15-20-22, 15-44, 15-46, 15-48, 15-49, 16-18-20

Approved storage container 9

Appurtenance 18, 1-20, 1-39, 1-86, 2-15, 2-32, 15-16-18, 16-12, 16-21

Aqueous 1-17, 13-53, 13-59, 13-94, 13-95

Aquifer 9, 2-45, 2-64

Archaeologic 12, 1-104

Architect 1, 1-58, 2-68

As low as reasonably achievable (ALARA) 1, 9, 1-42, 1-73, 1-76, 11-1, 13-3, 13-4, 13-9, 13-10, 13-13, 13-15, 13-47-50, 13-52, 13-58, 13-83, 13- 87, 13-102, 13-112, 13-113, 13-117, 15-44, 15-45, 15-48-50, 15-76

Asbestos 1, 1-55, 2-18, 9-1, 15-1, 15-61

Asbestos-cement board (ACB) 1

Asb 1-8, 2-2, 15-59, 15-74

Assembly cell 13-51, 13-57

Asset 2-56, 2-57, 13-17

Assistant Secretary for Defense Programs (DP1) 3

Atmosphere 22, 1-57, 8-3, 8-6, 11-4, 13-48, 13-78, 13-79, 13-93, 13-95, 13-113-115, 13-118, 13-121, 13-123, 13-126, 15-9, 15-13, 15-15, 15-28, 15-38, 15-44, 15-49, 15-73, 15-74, 16-2, 16-20

Atmospheric 5, 25, 1-29, 1-41, 2-6, 13-85, 13-125, 15-39, 15-45, 15-46

Atomic Vapor Laser Isotope Separation (AVLIS) 2, 13-70, 13-72, 13-73, 15-15

Attenuative capacity 2-66

Attractive 2-27, 13-17, 13-28, 13-29, 13-54, 13-59

Austenitic 1-22, 15-66, 15-67

Automated data processing (ADP) 1, 1-5, 1-32, 1-78, 1-80-84, 2-7, 13-2, 15-13, 15-14, 15-52, 16-9, 16-14, 16-15, 16-26

Auxiliary air unit 9

Auxiliary building 26

Auxiliary power 14, 1-79, 1-85, 1-87, 16-25

Auxiliary space 1-74

Auxiliary system 13-48, 13-78, 13-84, 13-87, 13-93, 13-124, 13-125

Aviation 3, 1-30, 2-28, 2-29

Axial 15-16, 15-41, 15-64, 15-65

Axial compressor 15-64

Axialpiston pump 15-65

Backslope 2-17

Backup 1-66, 1-67, 9-1, 13-23-26, 13-40, 13-114, 15-5, 15-8, 15-11, 15-32, 15-34, 15-46, 15-53, 15-76, 16-19

Balancing device 15-41-43

Ballast 9, 2-25, 16-8

Barbed wire 2-53, 2-58, 2-59

Barricade 19, 1-103

Double-hyphen entries indicate inclusive pages e.g., “3-27.29” means page 3-27 through page 3-29
Entries for singular words can include plurals.

Barrier 11, 12, 14, 16, 21, 23, 25, 28, 1-16, 1-37, 1-42, 1-56, 1-57, 1-68-70, 1-72, 1-73, 1-80, 1-85, 1-86, 1-96, 1-98, 2-17, 2-31, 2-38-40, 2-55-61, 7-1, 7-3-5, 8-2-4, 8-7, 9-7, 11-1-4, 13-8, 13-9, 13-12-14, 13-16, 13-19-22, 13-25, 13-27, 13-29, 13-45, 13-47-49, 13-54, 13-55, 13-60, 13-61, 13-74, 13-75, 13-79, 13- 80, 13-84, 13-89, 13-90, 13-95, 13-96, 13-98, 13-100, 13-107-110, 13-115, 13-118-120, 13-125, 13-126, 14-1, 14-2, 15-12-16, 15-41, 15-42, 15-47, 15-54, 15-69, 16-3, 16-6, 16-7

Base course 9, 27, 1-106, 7-1, 7-4, 7-5

Base Electronic System Engineering Plan (BESEP) 2

Baseline 1-70, 1-108, 13-16, 13-19

Baseline protection requirement 1-70, 13-19

Basement 1-38, 7-1, 7-4

Basic impulse insulation level (BIL) 2, 16-8

Bath 10-4

Battery area 15-53

Bay 15, 21, 27, 28, 1-74, 9-2, 9-7, 13-52, 13-58, 13-64-69, 15-13, 15-28, 15-51, 15-52

Bayonet joint 15-67

Bearing capacity 9, 2-21

Bellow 13-118, 15-60

Bench mark 10, 1-41, 1-108, 2-14, 2-15

Bentonite 10, 7-2, 7-3

Best available technology 2, 10, 13-56, 15-74

Best available technology economically achievable (BATEA) 2, 13-56

Best conventional pollutant control technology (BCPCT) 2

Bibb 15-19

Biochemical 2

Biochemical oxygen demand (BOD) 2

Biological agent 1-56

Bird strike 10, 2-65

Bitumen 7-11

Bituminous 1-20, 2-27, 2-60, 7-2-5, 7-11

Blast 22, 28, 1-28, 1-78, 1-93, 1-100, 13-64-67, 13-69

Block 1-63, 2-32, 4-1, 7-2, 7-13, 8-1, 15-22, 15-23, 15-27

Boiler 1, 1-14, 1-22, 1-28, 1-31, 1-40, 2-36, 8-6, 11-1, 13-5, 15-18, 15-20, 15-33, 15-35, 15-36, 15-43, 15-54-57, 15-59-61, 15-66, 15-68, 15-70, 15-81, 15-82

Boiler room 8-6, 15-60

Boiler water 15-59, 15-61

Bonding 1-27, 2-26, 2-60, 16-3, 16-23

Booster heater 15-18

Boring 10, 2-9, 2-10

Brake horsepower (BHP) 2, 15-36, 15-38, 15-81

Breathing air 13-11, 13-13, 13-39, 13-117, 13-123

Breeching 15-1

Brick 2, 29, 1-22, 1-24, 4-1, 7-1, 7-2, 7-5

Bridge 1-14, 1-15, 1-89, 1-106, 2-25, 2-53, 3-5, 16-23

British thermal unit (BTU) 2, 1-62, 1-63, 1-66-68, 15-5, 15-55-57, 15-83

Bubbler trap 13-119

Building acquisition 10, 1-1

Building addition 1-59, 1-63, 1-66, 1-92, 2-4, 16-12

Building Research Board (BRB) 2

Building Research Advisory Board (BRAB) 2

Building service 1-72, 2-34, 2-35, 16-14, 16-22

Buried storage tank 13-101

Cable 1-16, 1-78, 1-81, 1-84, 1-86, 1-94, 1-105, 2-7, 2-52, 5-2, 13-21, 15-73, 16-3, 16-7, 16-9, 16-24-26

Cable tray 16-3

Cable trench 1-84, 2-52

Cafeteria 2-7

Caisson 10

Calcined 22

Cantilever 10, 1-91

Canyon 15, 13-45, 13-88

Capacitor 16-5, 16-6, 16-12, 16-22

Capillary water 10, 7-3, 7-5

Capital cost 2-35, 2-56

Double-hyphen entries indicate inclusive pages, e.g., "3-27-29" means page 3-27 through page 3-29. Entries for singular words can include plurals.

Carbon dioxide (CO_2) 2, 1-38, 13-72, 15-7, 15-12, 15-14, 15-73

Carpet 2, 14, 1-8, 1-26, 9-6

Case 1-47, 1-54, 1-56, 1-62-67, 1-72, 1-77, 1-91, 1-97, 1-98, 1-102, 2-53, 2-60, 11-2, 13-9, 13-12, 13-13, 13-15, 13-17, 13-18, 13-21, 13-25, 13-26, 13-28, 13-29, 13-32, 13-41, 13-43, 13-46, 13-47, 13-54, 13-60, 13-72, 13-74, 13-78, 13-84, 13-89, 13-93-95, 13-99, 13-101, 13-109-112, 13-114, 13-119, 13-121, 13-122, 13-124, 15-3, 15-4, 15-10, 15-11, 15-13, 15-14, 15-38, 15-42, 15-45, 15-54, 15-56, 15-64, 15-66, 15-83, 16-13, 16-16, 16-17

Cased explosive 10, 13-68

Casework 12-1

Cast-in-place concrete 20, 2-22, 3-2, 3-3

Cast iron (CI) 2, 15-17, 15-35

Catchment 2-41

Cathode ray tube (CRT) 2, 1-41, 1-83, 13-40

Cathodic 1-109, 2-32, 2-48, 2-49, 15-61

Cavity wall 4-1, 7-4, 7-7

Ceiling 2, 27, 29, 1-23, 1-25, 1-33, 1-35, 1-56, 1-74, 1-75, 1-78, 1-81, 1-84, 1-86, 1-88, 1-95-97, 7-4, 7-9, 8-1-3, 9-1, 9-3-6, 13-25, 13-27, 13-33, 13-51, 15-9, 15-10, 15-19

Cement fiber 3-4

Cementitious 3-4, 7-2, 7-4, 7-5

Cementitious deck 3-4

Cementitious waterproofing 7-4

Centers and repeater stations 1-78

Central alarm station (CAS) 2, 1-17, 1-79, 1-86, 13-18, 13-24, 13-25

Central facility 15-55

Central plant heat 15-34, 15-54

Central station 1-19, 1-39, 1-79, 1-80, 13-28, 15-31, 15-34, 15-36, 15-82, 16-5

Centrifugal 1-19, 1-38, 13-79, 15-32, 15-36, 15-39, 15-63-65

Centrifugal compressor 15-32, 15-64

Centrifugal pump 15-65

Centrifugal separator 13-79

Centrifuge 13-70, 13-72, 13-73, 13-75, 15-14

Ceramic 29, 1-47, 9-3, 9-4, 13-77, 13-80, 15-33

Ceramic tile 1-47, 9-3, 9-4

Certification 1-27, 1-109, 1-110, 2-49, 15-38, 16-1

Change room 13-11, 13-89, 13-109, 15-26

Channel 14, 18, 28, 1-84, 1-86, 2-17, 2-40, 2-42, 3-4, 13-19, 13-25, 13-108, 16-19, 16-20

Chemical 9, 11, 12, 13, 15, 19, 24, 25, 1-22, 1-28, 1-38, 1-39, 1-56, 1-71, 1-73, 1-76, 1-104, 2-1, 2-4, 2-6, 2-7, 2-32, 2-35, 2-36, 2-48, 2-49, 13-6, 13-44, 13-45, 13-47, 13-52, 13-54, 13-57, 13-60, 13-63, 13-71, 13-76, 13-77, 13-79, 13-82, 13-88, 13-89, 13-93, 13-98, 13-99, 13-101, 13-102, 13-113, 13-123, 15-7, 15-18, 15-19, 15-33, 15-39, 15-44, 15-47, 15-49, 15-50, 15-59, 15-61, 16-27

Chemical additive 2-35

Chemical analysis 2-35

Chilled water 15-31-33, 15-35, 15-36, 15-81, 15-82

Chiller 2, 23, 11-1, 15-31, 15-32, 15-43, 15-55, 15-81, 15-82

Chlorinated polyvinyl chloride (CPVC) 2, 15-17

Chlorofluorocarbon (CFC) 2, 15-62, 15-63

Circulating pump 15-58

Class control 16-19, 16-20

Class instrumentation 16-18-20

Classified 10, 12, 15, 16, 18, 19, 20, 25, 26, 27, 28, 1-5, 1-11, 1-12, 1-27, 1-69, 1-79, 1-80, 1-82, 1-83, 1-86-88, 1-93, 2-7, 2-9, 2-62, 4-2, 9-5, 9-6, 13-2, 13-16, 13-19, 13-21, 13-32, 13-44, 13-75, 13-116, 13-121, 13-126, 13-127, 15-15, 15-20, 15-42, 15-75, 16-2, 16-20, 16-24, 16-26

Classified information 10, 25, 26, 1-79, 1-80, 1-83, 1-88, 9-5, 9-6, 16-2

Classified interest 10

Classified matter 10, 15, 20, 26, 28, 1-5, 1-11, 1-69, 1-79, 1-86, 1-87, 2-62, 13-2, 16-24, 16-26

Classified telecommunications facility 10

Cleaning 12, 1-18, 1-22, 1-25, 1-27, 1-28, 1-37, 1-74, 1-82, 8-2, 8-3, 11-2, 13-49, 13-51, 13-53, 13-58, 13-70, 13-72, 13-75, 13-80, 13-113-115, 15-23, 15-29, 15-33, 15-38, 15-39, 15-47, 15-48, 15-70, 15-74, 15-75

Cleanup 2-18, 2-48, 13-13, 13-82, 13-83, 13-89, 13-109, 13-113, 13-118, 13-120, 13-123-125, 15-7, 15-44, 15-45, 15-48, 15-50

Climate 1-104, 2-5, 2-35, 2-38, 2-70, 13-37, 15-38

Climatic 1-89, 1-104, 2-68, 2-70, 3-3, 15-27, 15-61

Closed circuit television (CCTV) 2, 13-24, 13-29, 13-103

Closet 1-107, 1-110

Coal 1-40, 4-2, 15-57, 15-58, 15-72-74

Coating 1-18, 1-23, 1-37, 1-44, 2-32, 2-60, 5-3, 7-1, 7-4, 7-5, 8-8, 9-1, 9-2, 9-6, 9-7, 12-1, 13-51, 15-33

Coaxial cable 16-26

Cogeneration 1-65, 15-54, 15-56, 16-5

Coil 1-19, 2-59, 15-30, 15-31, 15-36-39, 15-41, 15-43, 15-63, 15-81, 15-82

Coiling door 8-5

Cold storage room 7-8

Cold weather concreting 1-15, 3-3

Collection system 1-104, 2-37, 2-50, 13-8, 13-86, 13-95, 13-98, 13-102, 13-111, 15-21, 15-22, 15-50-52

Color 1-53, 4-2, 7-9, 7-11, 13-40, 13-41, 13-43, 16-4, 16-15

Combustible 1-39, 1-79, 1-82, 1-98, 2-32, 11-2, 11-3, 13-48, 13-53, 13-59, 15-3, 15-7, 15-12, 15-69, 15-70, 16-20

Combustion 1-31, 1-39, 1-55, 11-4, 13-88, 15-13, 15-30, 15-47, 15-59, 15-60, 15-72-75, 15-80

Combustion process installation 15-72

Comfort 1-71, 13-37, 13-40, 15-25-27, 15-52, 15-78

Communications 19, 25, 26, 1-10, 1-20, 1-52, 1-71, 1-78-80, 1-82, 1-85, 1-86, 1-96, 1-108, 1-109, 2-8, 2-52, 2-53, 2-61, 13-18, 13-24, 13-25, 13-28, 13-34, 13-38, 13-42, 14-1, 14-2, 16-6, 16-7, 16-10, 16-13, 16-14, 16-16, 16-21, 16-24, 16-26, 16-27

Community facility 1-77

Compaction 1-108, 1-109, 2-11, 2-49, 13-106

Compartment 11, 21, 27, 1-74, 1-79, 10-1, 13-7, 13-13, 13-52-55, 13-58-61, 13-75, 13-80, 13-90, 13-96, 13-110, 13-114, 13-120, 13-125, 13-126

Compartmentalization 1-74, 1-75, 13-53, 13-59

Compressed air 15-39

Compressed gas 2, 1-25, 1-72,

Compression joint 15-67

Compressor 1-19, 1-49, 2-23, 13-7, 13-73, 15-32, 15-63, 15-64, 15-77, 15-82, 16-12

Compromise joint bar 2-24

Computer 2, 6, 1-10, 1-12, 1-27, 1-39, 1-62, 1-63, 1-66, 1-80-84, 2-9, 2-42, 8-2, 9-6, 13-32, 15-14, 15-31, 15-32, 15-52, 16-13, 16-27

Computer Security Operations Manager (CSOM) 2, 1-83, 1-84, 16-26

Computer System Security Officer (CSSO) 2, 1-80, 1-83

Conceptual Design Report (CDR) 2, 1-104, 2-2, 2-5, 2-58

Concrete 1, 2, 5, 6, 7, 10, 11, 14, 17, 20, 22, 24, 25, 26, 27, 28, 29, 1-8, 1-15-17, 1-22, 1-37, 1-38, 1-42, 1-44, 1-75, 1-82, 1-87, 1-94-96, 1-101, 1-108, 1-109, 2-12, 2-22, 2-24, 2-27, 2-28, 2-38, 2-58, 2-60, 3-1-5, 5-3, 7-1, 7-2, 7-4, 7-5, 7-7, 7-9, 9-2, 9-3, 9-7, 13-9, 13-86, 13-109, 15-22, 15-60, 15-70, 15-74, 16-2, 16-7

Concrete pipe (CP) 2, 7

Condensate 2-50, 15-34-36, 15-38, 15-55, 15-59, 15-61

Condensation 7-6, 15-1, 15-41

Condenser 1-19, 1-21, 13-95, 13-100, 15-27, 15-31-33, 15-35, 15-36, 15-43, 15-48, 15-82

Condensing unit 1-19, 2-69, 15-33

Conductivity 2-50, 2-66, 8-2, 9-5, 9-6, 13-102, 13-107

Conductor 1-22, 16-2-4, 16-6, 16-7, 16-9-11, 16-13, 16-23, 16-24, 16-27

Conduit 4, 1-78, 1-88, 2-49, 7-9, 11-2, 11-3, 13-23, 13-33, 13-45, 15-21, 15-60, 15-77, 16-2, 16-7, 16-24, 16-25

Conduit connection 1-78

Conference room, see Secure conference room

Confinement 11, 12, 15, 22, 29, 1-42, 1-57, 1-73, 1-75, 1-98, 1-100, 11-1-4, 13-4, 13-7-10, 13-12-14, 13-33, 13-46-49, 13-52, 13-54, 13-55, 13-57, 13-58, 13-60-62, 13-66, 13-72, 13-74, 13-75, 13- 77-80, 13-84, 13-87-90, 13-93, 13-95, 13-96, 13-98-104, 13-106-110, 13-112-115, 13-118-120, 13-122-126, 15-11-13, 15-21, 15-24, 15-40, 15-42, 15-44-49, 15-71, 15-76, 16-19

Confinement area 11, 22, 29, 13-7, 13-13, 13-57, 13-62, 13-74, 13-75, 13-90, 13-110, 13-120, 13-125, 13-126, 15-76

Confinement system 11, 15, 22, 1-73, 1-98, 13-4, 13-7, 13-12, 13-13, 13-46-49, 13-54, 13-55, 13-60, 13-61, 13-66, 13-74, 13-77-80, 13-84, 13-88-90, 13- 93, 13-95, 13-96, 13-99, 13-101-103, 13-107-110, 13-112-115, 13-119, 13-120, 13-124, 13-125, 15-11-13, 15-42, 15-48, 15-71, 16-19

Confinement ventilation 1-73, 13-114, 13-115, 13-120, 15-44, 15-45

Consolidation 1-75, 1-94

Construction 1-103-110, 2-16

Construction facility 1-103

Construction joint 11, 7-2, 7-5

Construction project 11, 1-58

Double-hyphen entries indicate inclusive pages, e.g., “3-27-29” means page 3-27 through page 3-29. Entries for singular words can include plurals.

Construction project planning 11

Construction specification 2, 1-3, 1-102, 2-10

Containment 1-56, 1-57, 1-72, 2-47, 2-48, 7-1, 9-1, 13-19, 13-27, 13-29, 13-67, 13-69, 13-118, 13-123-125, 15-40, 15-58

Contaminant 12, 1-71, 1-76, 1-106, 2-6, 2-33, 2-65, 9-1, 11-2, 11-4, 11-5, 13-16, 13-50, 13-57, 13-62, 13-75, 13-98, 13-110, 13-114, 15-22, 15-28-30, 15-39, 15-41, 15-45, 15-48, 15-49, 15-71

Contaminated liquid waste 13-50, 13-81, 13-96, 13-98, 13-103, 13-104, 13-115, 13-120

Contaminated solid waste 2-68, 13-49, 13-80, 13-96, 13-104-106, 13-120

Contamination 12, 1-56, 1-71, 1-74, 1-77, 2-47, 2-64, 9-1, 11-1, 11-3, 11-4, 13-7, 13-10, 13-11, 13-14, 13-33, 13-48, 13-51, 13-55, 13-61, 13-68, 13-75, 13-78-85, 13-87, 13-89, 13-90, 13-93, 13-95, 13- 96, 13-109, 13-110, 13-114, 13-116, 13-120, 13-121, 13-126, 15-18, 15-21, 15-24, 15-42, 15-44, 15-45, 15-47, 15-49-52, 16-7, 16-21

Contingency plan 2-67

Continuous Air Monitoring System (CAMS) 2, 13-10, 13-11

Continuous emissions monitoring (CEM) 2, 15-73

Control 2, 3, 4, 5, 7, 8, 10, 13-16, 18, 20, 21, 22, 23, 24, 25, 26, 28, 1-9-12, 1-16-18, 1-20, 1-21, 1-29, 1-30, 1-38, 1-41, 1-44, 1-47-49, 1-52, 1-55-57, 1-65-70, 1-72-74, 1-78, 1-80-86, 1-93, 1-96, 1-101-103, 1-105, 1-106, 1-108, 2-3, 2-7, 2-8, 2-11-15, 2-19, 2-27, 2-28, 2-31, 2-32, 2-35, 2-39, 2-40, 2-43, 2-46-48, 2-50, 2-53-56, 2-58, 2-60, 2-61, 2-67, 2-69, 3-2, 3-3, 7-2, 7-5, 9-3-5, 9-7, 10-4, 11-3-5, 12-1, 13-5, 13-7-11, 13-14-23, 13-25-28, 13-33, 13-34, 13-36-41, 13-43-46, 13-48-50, 13-53, 13-54, 13-56, 13-59, 13-61, 13- 63, 13-65, 13-67, 13-70-75, 13-77, 13-79, 13-80, 13-85-87, 13-91-96, 13-98, 13-99, 13-102, 13-104, 13-106-108, 13- 111, 13-114, 13-115, 13-120, 13-126, 14-1, 14-2, 15-3, 15-7, 15-11-14, 15-18-21, 15-25, 15-27-30, 15-32, 15-33, 15-35-38, 15-41, 15-43, 15-44, 15-46, 15-47, 15-49, 15-50, 15- 52-54, 15-58, 15-60, 15-66, 15-69, 15-71-73, 15-75, 15-77-83, 16-3, 16-12-14, 16-17-20, 16-23, 16-26, 16-28

Control area 13-18, 16-20

Control center 3, 13, 14, 1-84, 1-85, 2-8, 9-4, 13-23, 15-3, 15-14, 15-52, 15-53, 16-14

Control damper 15-79

Control joint 1-96

Control monument 10, 2-12, 2-13, 2-15

Control panel 13-37, 13-39, 13-40, 13-43, 15-60, 15-77

Control setback 15-78

Control valve 15-11, 15-35, 15-43, 15-81, 15-82

Control zone 1-83, 1-84, 16-26

Controller 1-37, 1-62, 15-77, 15-79, 15-81, 16-12, 16-13

Conversion 8, 21, 1-5, 2-55, 13-2, 13-33, 13-72, 13-73, 13-76, 13-92, 13-94, 13-117, 13-123, 15-15, 15-34, 15-71, 15-72, 16-20

Conveyance 12, 14, 18, 1-105, 2-42, 2-70, 14-1-3

Cooling 2, 5, 1-15, 1-19, 1-22, 1-26, 1-36, 1-59, 1-61-64, 1-71, 1-82, 2-15, 2-68, 2-69, 7-10, 13-7, 13-11, 13-48, 13-54, 13-60, 13-72-74, 13-82, 13-83, 13-86, 13-98, 13-99, 13-102, 13-106, 13-107, 13-114, 13-118, 13-123, 15-3, 15-20-22, 15-24-28, 15-30-33, 15-36, 15-38, 15-41, 15-43, 15-52, 15-53, 15-64, 15-78, 15-79, 15-81, 15-82, 16-8, 16-19

Cooling tower 2, 1-26, 7-10, 13-11, 15-3, 15-27, 15-31, 15-33, 15-82

Copper 1-22, 2-35, 2-59, 15-17, 15-67, 15-77, 16-3, 16-4

Corridor 1-58, 1-74, 1-75, 1-78, 2-17, 2-31, 2-33, 2-37, 9-3, 15-51, 16-6

Corrosion 16, 1-23, 2-31, 2-32, 2-35, 2-48, 2-49, 7-7, 8-1, 9-5, 10-1-4, 11-2, 13-48, 13-55, 13-60, 13-84, 13-94, 13-102, 13-107, 15-23, 15-38, 15-59, 15-61

Corrosivity 11, 2-35

Corrugated metal pipe (CMP) 2

Cost 5, 7, 10, 11, 20, 27, 1-2, 1-29, 1-34, 1-37, 1-51, 1-52, 1-54, 1-56, 1-58, 1-60, 1-62, 1-65, 1-67, 1-74, 1-83, 1-90, 2-7, 2-17, 2-21, 2-22, 2-35, 2-37, 2-39, 2-40, 2-42, 2-44, 2-46, 2-47, 2-56, 2-64, 2-69, 2-70, 13-9, 13-17, 13-34, 13-35, 13-42, 13-49, 15-3, 15-6, 15-19, 15-25, 15-34, 15-37, 15-38, 15-40, 15-56-62, 15-64, 15-68, 15-69, 15-72, 15-78, 15-83, 16-5, 16-7-9

Countermeasure 7, 1-12, 1-28

Cover 11, 1-3, 1-60, 2-18, 2-26, 2-29, 2-31, 2-32, 2-35, 2-38, 2-40, 2-41, 2-65, 2-69, 2-70, 3-1-5, 4-1, 5-1, 6-1, 7-1, 7-2, 10-3, 11-3, 13-2, 13-11, 13-30, 13-34, 13-50, 13-72, 13-90, 13-108, 15-4, 15-23, 15-42, 15-76, 15-77, 16-7

Crack 13-33, 13-51, 15-51, 16-23

Crane 1-25, 1-26, 1-96, 1-100, 14-3, 15-69

Creep 1-95

Critical area 11, 1-75, 15-32

Critical facility 11, 14, 1-93, 2-9, 2-28, 2-42, 13-24, 13-64

Criticality 11, 13, 22, 25, 1-17, 1-18, 1-42, 1-74, 1-76, 1-97, 1-98, 1-100, 2-51, 2-68, 11-2, 13-3, 13-5, 13-7, 13-8, 13-11, 13-30, 13-44, 13-49, 13-50, 13-52, 13-53, 13-56, 13-57, 13-59-63, 13-68, 13-70-72, 13-74-77, 13- 80-82, 13-85-87, 13-91-99, 13-104, 13-106, 13-107, 13-111, 13-112, 13-117, 13-122, 13-123, 15-11, 15-12, 15-21, 15-50, 15-76, 16-19

Double-hyphen entries indicate inclusive pages, e.g., “3-27-29” means page 3-27 through page 3-29. Entries for singular words can include plurals.

Criticality incident 11

Cross-connections 15-18, 15-35

Cross-contamination 1-71, 13-78, 13-93, 15-42

Crossing frog 11

Crown, roadway 11

Cryogenic 1-20, 13-122, 15-63, 15-65-70

Crypto 10, 12, 1-83

Cubicle 15, 10-1, 11-1, 15-51

Cultural resource 12, 1-104

Curb 12, 1-6, 2-16, 2-17, 2-26, 2-27, 2-42, 2-43, 2-54, 2-56, 7-10, 7-12

Curb inlet 12, 2-42

Curb return 12, 2-42

Curtain 8-3, 8-5, 12-2

Cylinder 1-25, 1-72, 1-108, 13-45, 13-46, 13-71, 13-72, 13-76, 13-92, 13-93, 15-32

Cylinder handling area 13-71

Dampproofing 1-16, 1-24, 7-1, 7-2, 7-4, 7-5, 9-7

Datum 5, 12

Daylighting 1-61

Dead load (DL) 3, 12, 1-91

Deck 7, 1-45, 3-4, 5-3, 7-8-10, 9-5

Decommissioning 12, 1-2, 1-53, 1-71, 1-75, 1-106, 2-18, 13-33, 13-51, 13-69, 13-81, 13-86, 13-91, 13-97, 13-116, 13-121, 13-126

Decontaminate 1-53, 15-48

Decontamination 12, 21, 1-71, 1-75, 1-77, 1-106, 2-18, 9-2, 9-3, 13-11, 13-13, 13-33, 13-34, 13-51, 13-56, 13-61, 13-69, 13-70, 13-75, 13-78, 13-81, 13-86, 13-91, 13-93, 13-97, 13-98, 13- 111, 13-115, 13-116, 13-120, 13-121, 13-126, 14-2, 15-22

Decontamination waste 13-56, 13-91

Dedicated fire water system 12

Deflagration 12

Deflection angle 12, 2-16

Deluge 24, 1-38, 15-6, 15-13

Demolition 1-55, 1-106, 2-18, 13-33

Departmental-approved equipment 12

Departmental element 12, 1-7

Derived air concentration (DAC) 3, 13-45, 13-78

Derived concentration guide (DCG) 3, 13-15

Design basis accident (DBA) 3, 9, 11, 12, 13, 14, 21, 22, 25, 1-73, 1-75, 1-76, 1-100, 2-5, 11-2, 13-3-6, 13-11-13, 13-15, 13-45-49, 13-52-55, 13-57-61, 13-64, 13-66, 13-74, 13-79, 13- 80, 13-82, 13-84, 13-87-90, 13-95, 13-96, 13-101, 13-102, 13-107, 13-109, 13-110, 13-113-115, 13-118-120, 13-123-125, 13-127, 15-11, 15-20-22, 15-44-50, 15-76, 16-19, 16-20

Design basis earthquake (DBE) 3, 13, 24, 1-54, 1-98, 1-99, 13-6, 13-9, 13-13, 13-47, 13-48, 13-52, 13-55, 13-57, 13-61, 13-82, 13-87, 13-101, 13-109, 13-110, 15-12, 15-20, 15-22, 15-44, 15-45, 16-18

Design basis fire (DBF) 3, 9, 13, 1-54, 1-75, 13-12, 13-48, 13-90, 13-102, 13-110, 13-115, 15-11, 15-12, 15-21, 15-47

Design basis flood (DBFL) 3, 13, 1-54

Design basis tornado (DBT) 1-54, 1-98, 1-99, 3, 13, 13-49

Design basis wind (DBW) 3, 1-54

Design document 1-101, 1-102, 1-108

Design speed 2-56

Detection 4, 12, 13, 19, 20, 1-47, 1-52, 1-56, 1-70, 1-75, 1-79, 1-87, 1-108, 2-16, 2-27, 2-44, 2-50, 2-59, 2-61, 11-4, 13-19-24, 13-26, 13-27, 13-32, 13-45, 13-48, 13-66, 13-86, 13-118, 13-123, 14-1, 15-4, 15-6, 15-8, 15-9, 15-11-14, 15-47, 15-52, 15-76, 15-77, 15-80, 15-83, 16-18

Detection equipment 13, 13-22, 15-47

Detonation 10, 12, 13, 16, 17, 19, 13-63, 13-66, 13-69

Detonator 13, 18, 19

Developed area 2-41, 2-42

Deviation 1-2, 1-3, 1-61, 1-102, 5-1, 5-2, 13-1, 13-4

Dewatering 1-20, 2-11, 2-19, 2-20

Diaphragm 1-45, 13-118, 15-39, 15-64

Diaphragm compressor 15-64

Dielectric 15-17

Differential scanning calorimetry (DSC) 3, 16-21

Differential thermal analysis (DTA) 3, 16-21

Dike 1-104, 13-100, 13-101, 13-103, 16-8

Double-hyphen entries indicate inclusive pages, e.g., “3-27-29” means page 3-27 through page 3-29. Entries for singular words can include plurals.

Dioctylphthalate (DOP) 3, 17

Direct current (DC) 3, 1-7, 1-9, 1-10, 1-12-14, 1-16, 1-19, 1-27-31, 1-37, 1-38, 1-41, 1-43, 1-45, 1-50, 16-14, 16-17, 16-18

Director of Safeguards and Security Agreement (DP34) 3, 27, 1-47

Discharge 4, 5, 17, 19, 21, 23, 24, 1-8, 1-106, 2-38-42, 2-44, 2-45, 2-50, 7-3, 7-10, 7-13, 13-15, 13-28, 13-50, 13-56, 13-104, 13-105, 13-114, 15-6, 15-19, 15-22, 15-32, 15-33, 15-35, 15-36, 15-38, 15-41, 15-43, 15-45, 15-64, 15-65, 15-71, 15-73, 15-76, 15-80-82, 16-8, 16-11, 16-23

Dismantlement 13-34

Dispensary 1-77

Dispersion 2-3, 2-18, 9-1, 13-72, 13-74, 13-89, 15-22, 15-28, 15-45, 15-73

Display device 13-40

Disposal 8, 16, 20, 25, 1-7-9, 1-29, 1-55, 1-71, 1-104, 1-106, 2-18, 2-20, 2-43-47, 2-50, 2-67, 2-68, 2-70, 11-3, 13-14, 13-34, 13-56, 13-83, 13-104-108, 13-110, 13-111, 15-51, 15-59, 15-71, 15-74, 15-75

Dissolver area 13-87

Distribution 11, 12, 14, 16, 20, 1-9, 1-10, 1-13, 1-25, 1-34, 1-59, 1-60, 1-62-64, 1-66, 1-67, 1-72, 1-83, 1-104, 2-6, 2-7, 2-15, 2-31, 2-33-35, 2-40, 2-42, 13-7, 13-102, 14-1, 14-2, 15-1, 15-10, 15-12, 15-15, 15-28-31, 15-33-37, 15-39-43, 15-48, 15-52, 15-54, 15-55, 15-57-61, 15-81, 16-6, 16-7, 16-9, 16-11, 16-13, 16-14, 16-18, 16-24, 16-27

Diversity factor 16-5, 16-10

Document improvement proposal 1-6

DOE buildings, naming 10-2

DOE Energy Management Coordinator 13, 1-61, 1-62, 1-64-67

DOE Fire Protection Authority 13, 1-55, 1-56, 11-2, 15-5, 15-10, 15-40

DOE Office of Scientific and Technical Information (OSTI) 6, 1-27, 1-28, 1-35

DOE Safeguards and Security Coordinator 13

DOE Safeguards and Security Coordinator 1-28, 2-56, 2-57, 13-26

Domestic 9, 25, 1-62-67, 2-31, 2-33, 2-34, 2-38, 2-44, 2-45, 2-64, 13-26, 15-10, 15-16, 15-17, 15-31

Door 4, 6, 7, 27, 29, 1-6, 1-14, 1-18, 1-32, 1-35, 1-39, 1-43, 1-45, 1-46, 1-48, 1-61, 1-68, 1-69, 1-72, 1-74-76, 1-78, 1-85-88, 2-62, 7-8, 8-1, 8-2, 8-4-7, 9-3, 9-5, 9-6, 10-4, 11-3, 13-13, 13-21, 13-23, 13-26, 13-28, 13-29, 13-53, 13-59, 15-44, 15-52

Dose 3, 5, 14, 24, 2-2, 2-3, 13-4, 13-8-10, 13-48, 13-58, 13-85, 13-105, 13-106, 15-45, 15-48

Dose rate 13-9

Downdraft ventilation 15-44

Draft 1-19, 1-21, 1-47, 2-48-50, 15-58, 15-73

Draft auxiliary 15-73

Drain 2-17, 2-23, 2-28, 2-31, 2-40, 2-42, 2-45, 2-50, 7-3, 7-12, 7-13, 11-2, 13-32, 13-50, 13-56, 13-77, 13-92, 13-98, 13-99, 15-16, 15-17, 15-19, 15-22, 15-23, 15-36, 15-38, 15-49, 15-61, 15-74

Drainage 9, 23, 1-30, 1-103, 1-104, 1-106, 2-6, 2-11, 2-16, 2-17, 2-19, 2-23, 2-26, 2-27, 2-30, 2-39-42, 2-44, 2-56-58, 7-3, 7-5, 7-10, 7-12, 7-13, 15-22, 15-24, 15-41, 16-8

Drapery 1-48, 12-2

Drilling 15, 1-23, 2-9, 2-10

Drilling fluid 2-10

Dry chemical 1-38, 15-7

Dry pipe 15-6, 16-23

Dry wall 9-3

Ductwork 11-2, 11-4, 13-33, 13-34, 13-50, 13-51, 15-1, 15-37, 15-38, 15-40, 15-41, 15-45, 15-47, 15-54, 15-79, 15-80

Dumping 15-75

Duress system 13, 2-61, 13-25

Dust 1-20, 1-78, 1-82, 1-103, 1-105, 1-106, 2-7, 13-38, 13-48, 13-50, 13-78, 13-80, 13-81, 13-84, 13-95, 13-96, 15-28, 15-29, 15-39, 15-46, 15-50-52, 15-71, 15-74, 16-20, 16-21, 16-27

Earth 14, 22, 26, 27, 1-38, 1-91, 1-94, 2-10, 2-20, 2-42, 2-60, 7-1-4

Earth pressure 1-91, 1-94, 2-10

Earthquake 3, 6, 7, 13, 24, 1-42, 1-54, 1-75, 1-90, 1-91, 1-93, 1-94, 1-96, 1-97, 1-99, 1-100, 2-4, 2-9, 9-3, 11-2, 16-7

Earthwork 2-20, 2-21

Easement 2-17

Effective Dose Equivalent (EDE) 3, 14, 2-3, 13-9

Efficiency 4, 17, 27, 1-28, 1-48, 1-53, 1-60, 1-64, 1-74, 2-1, 2-7, 2-8, 2-30, 2-61, 11-1, 13-7, 13-73, 15-27, 15-28, 15-36, 15-39, 15-54, 15-56, 15-58, 15-75, 16-12, 16-15

Double-hyphen entries indicate inclusive pages, e.g., “3-27-29” means page 3-27 through page 3-29. Entries for singular words can include plurals.

Effluent 10, 14, 20, 24, 1-11, 1-18, 2-6, 2-45, 2-51, 2-68, 13-4, 13-10-12, 13-14, 13-15, 13-34, 13-46, 13-49, 13-50, 13-56, 13-57, 13-61, 13-62, 13-75, 13-80, 13-81, 13-85, 13-87, 13-91, 13- 96, 13-97, 13-99, 13-102, 13-104, 13-111, 13-112, 13-115, 13-116, 13-118-121, 13-126, 15-24, 15-39, 15-40, 15-47, 15-48, 15-58, 15-59, 15-73, 15-76

Egress 14, 1-71, 2-58, 2-61, 2-63, 13-8, 13-29, 13-54, 13-60, 15-70

Elastomeric 7-2, 7-5, 7-11, 15-17

Electric 27, 1-9, 1-18, 1-26, 1-27, 1-29, 1-31, 1-34, 1-86, 2-17, 2-19, 13-25, 13-71, 13-73, 13-74, 13-122, 15-3, 15-8, 15-12, 15-14, 15-17, 15-32, 15-35, 15-44, 15-47, 15-49, 15-57-59, 15-65, 15-79, 15-81, 16-5-9, 16-11-13, 16-17-21, 16-24, 16-28

Electric space heating 16-28

Electrical 3, 4, 5, 18, 1-18, 1-20, 1-27, 1-31, 1-32, 1-34, 1-38-40, 1-53, 1-60, 1-64, 1-69, 1-72, 1-76, 1-79, 1-87, 1-88, 1-90, 1-96, 1- 104, 1-108, 1-110, 2-7, 2-8, 2-17, 2-26, 2-32, 2-52, 2-55, 2-58-60, 5-2, 8-6, 9-4, 13-6, 13-23, 13-26, 13-68, 13-88, 15-12-15, 15-17, 15-22, 15-30, 15-39, 15-44, 15-49, 15-65, 15-77, 15-82, 16-1-3, 16-5, 16-6, 16-8, 16-10, 16-11, 16-14, 16-16-23, 16-27, 16-28

Electrical interference 2-7, 16-6

Electrical metallic tubing (EMT) 3, 16-2

Electrical potential 2-26

Electrically conductive floor 9-6

Electro Explosive Device (EED) 3, 14

Electroanalogous 2-19

Electrode 2-26

Electronic air cleaner 15-39, 15-42

Elevation 17, 24, 1-109, 2-10, 2-12, 2-14-17, 2-20, 2-34, 15-26, 16-7

Elevation contour 2-16

Elevator 1-6, 1-22, 1-96, 14-1-3, 15-74

Emergency 3, 14, 29, 1-4, 1-11, 1-19, 1-26, 1-31, 1-32, 1-34, 1-39, 1-40, 1-52-54, 1-57, 1-68, 1-71, 1-73, 1-76, 1-77, 1-79, 1-84, 1- 86, 1-109, 2-2, 2-3, 2-5, 2-8, 2-30, 2-48, 2-52, 2-54, 2-55, 2-58, 2-61-63, 8-2, 8-7, 9-2, 9-3, 11-4, 13-2, 13-7, 13-10, 13-13, 13-24-27, 13-36, 13-38-40, 13-42, 13-46, 13-69, 13-71, 13-82, 13-114, 13-118, 13-120, 13-123, 14-2, 15-4, 15-8, 15-12, 15-13, 15-18, 15-20, 15-22, 15-24, 15-44, 15-46, 15-47, 15-53, 15-71, 16-8, 16-11, 16-14-18, 16-24, 16-25

Emergency Control Center (ECC) 3, 14, 1-76

Emergency Control Station (ECS) 3, 14, 1-76

Emergency equipment 1-52, 13-13, 16-11

Emergency exit 8-2, 8-7

Emergency management 3, 1-11, 1-31, 1-53

Emergency Operating Center (EOC) 3, 14, 1-76

Emergency planning 14, 1-11, 1-52

Emergency power 3, 14, 29, 2-52, 2-61, 11-4, 13-71, 15-12, 15-44, 15-46, 15-47, 16-8, 16-14, 16-16, 16-17, 16-24, 16-25

Emergency power system (EPS) 3, 14, 2-61, 16-16, 16-17

Emergency preparedness 1-4, 1-53, 1-54, 1-76, 13-2, 15-13, 16-14

Emergency response 14, 2-2, 2-3, 15-71

Emergency shower 13-39, 15-18

Emergency vehicle 2-5, 2-54, 2-58

Emission 2, 14, 1-8, 1-10, 1-105, 9-2, 12-1, 15-3, 15-14, 15-15, 15-71-75

Encasement 14, 2-50, 13-13, 13-56, 13-102

Enclosure 11, 15, 21, 27, 1-40, 1-78, 1-83, 1-87, 1-98, 2-49, 11-1-5, 13-3, 13-13, 13-23, 13-33, 13-37, 13-44, 13-45, 13-47, 13-48, 13-55, 13-61, 13-72-74, 13-77-79, 13-84, 13-92-95, 13-98, 13- 112, 13-114, 13-119, 14-1, 15-10, 15-15, 15-46-48, 15-52, 15-74, 16-12

Endangered 2-64

Energy 1, 3, 13, 15, 16, 17, 18, 23, 24, 25, 27, 28, 1-4, 1-7, 1-8, 1-10, 1-11, 1-13, 1-17, 1-20, 1-21, 1-23, 1-27, 1-33-37, 1-46, 1-52, 1-59-68, 1-71, 1-73, 1-74, 1- 93, 1-100, 1-109, 2-1, 2-2, 2-4, 2-34, 2-36, 2-44, 2-45, 2-47, 2-52, 2-68, 7-6, 7-7, 7-9, 7-11, 8-1, 10-3, 10-4, 11-1, 12-1, 12-2, 13-67, 13-68, 13-89, 13-123, 15-1, 15-18, 15-25, 15-30-32, 15-35, 15-37, 15-40, 15-52, 15-54-56, 15-58, 15-65, 15-75-81, 15-83, 16-3, 16-8, 16-12, 16-15, 16-26, 16-28

Energy conservation 23, 1-4, 1-7, 1-21, 1-34, 1-59, 1-60, 1-62-68, 1-71, report 1-60, 1-62, 1-63, 1-65-67, 2-2, 2-4, 2-34, 2-36, 2-68, 7-6, 7-7, 7-9, 7-11, 8-1, 10-4, 11-1, 12-1, 12-2, 15-25, 15-30, 15-31, 15-37, 15-77, 16-15, 16-28

Energy conservation report 1-66-67, 15-31

Energy management 1-7, 1-10, 1-27, 1-37, 1-52, 1-61, 1-62, 1-64-67, 1-109, 2-1, 2-52, 3, 13, 15, 15-83, 16-12, 16-26, 16-28

Energy management system (EMS) 3, 15, 1-52, 1-62, 1-109, 2-52, 15-78, 15-83, 16-12, 16-26, 16-28

Energy monitoring and control system (EMCS) 15, 1-20

Engine 1-31, 1-39, 1-79, 1-84, 2-23, 15-53, 15-59, 16-17, 16-24

Double-hyphen entries indicate inclusive pages, e.g., "3-27-29" means page 3-27 through page 3-29. Entries for singular words can include plurals.

Engineered Safety Feature (ESF) 3, 15, 2-3

Entry Control Point (ECP) 3, 15, 2-58, 2-61

Envelope 1-60, 1-61, 1-63-67, 1-88, 1-89, 7-6, 11-2, 13-13, 15-25, 15-53

Environment 11, 12, 14, 18, 19, 22, 24, 25, 30, 1-9, 1-11, 1-12, 1-51, 1-54, 1-56, 1-60, 1-74, 1-82, 1-91, 1-97, 1-103, 1-106, 2-2, 2-4, 2-5, 2-31, 2-33, 2-47, 2-50, 2-61, 8-1, 8-4, 9-5, 10-1-4, 11-1-3, 13-4-6, 13-12, 13-15, 13-16, 13-31, 13-34, 13-37, 13-39, 13-41, 13-45, 13-47-50, 13-52, 13-56, 13-58, 13-79, 13-87, 13-95, 13- 99, 13-104, 13-105, 13-112, 13-118, 13-125, 15-22, 15-30, 15-42, 15-44, 15-45, 15-47, 15-49, 15-50, 15-71, 15-76, 16-17-19

Environmental 2, 3, 5, 9, 10, 16, 17, 18, 1-2, 1-3, 1-8-12, 1-17, 1-21, 1-29, 1-57, 1-64, 1-73, 1-82, 1-105, 2-1, 2-2, 2-4, 2-5, 2-8, 2-18, 2-34, 2-36, 2-43, 2-45-47, 2-64, 9-2, 13-3, 13-4, 13-6, 13-10, 13-15, 13-16, 13-32, 13-37, 13-38, 13-43, 13-50, 13-97, 13-98, 13-101, 13-103, 13-105, 13-124, 15-24, 15-25, 15-39, 15-53, 15-56, 15-59, 15-62, 15-71, 15-74-76, 16-19

Environmental degradation 13-38

Environmental design temperature 15-25

Environmental Impact Statement (EIS) 3

Environmental qualification of equipment 13-6

Environmentally sensitive 2-64, 15-78

EPA identification number 2-63

Epoxy mortar 1-15, 3-4

Equipment 10, 12, 13, 14, 16, 18, 19, 21, 23, 25, 27, 29, 1-10, 1-11, 1-18, 1-19, 1-21, 1-25, 1-27, 1-31, 1-33, 1-34, 1-39, 1-40, 1-46, 1-48, 1-52-60, 1-63-65, 1- 69, 1-71-76, 1-78-86, 1-88, 1-90, 1-93, 1-94, 1-96-98, 1-100, 1-106, 1-108, 1-110, 2-5, 2-7, 2-8, 2-11, 2-13, 2-14, 2-17, 2-18, 2-23, 2-28, 2-31, 2-48, 2-49, 2-54, 2-58, 2-61, 2-63, 2-68, 2-69, 7-10, 7-13, 8-2, 8-3, 8-5, 8-6, 9-4-6, 10-3, 11-1-3, 11-5, 13-6, 13-7, 13-9-11, 13-13-25, 13-27, 13-29-32, 13-34-43, 13-46-49, 13-51-53, 13-55, 13-56, 13-58-62, 13-66, 13- 68-74, 13-77-81, 13-84, 13-85, 13-87-89, 13-91, 13-93-97, 13-99-102, 13-107, 13-109, 13-113-115, 13- 118-121, 13-123, 13-124, 13-126, 14-1, 14-3, 15-1, 15-9, 15-12-15, 15-17-39, 15-43, 15-44, 15-46-49, 15-52, 15-53, 15-58-63, 15-68-70, 15-72-77, 15-82, 16-1, 16-2, 16-4, 16-6, 16-8-21, 16-23-28

Equipment foundation 2-23

Equipment installation 1-53, 1-73, 1-75, 15-69

Equipment operability 13-6, 15-22

Equipment room 1-81, 7-10, 8-6, 9-5, 15-30, 15-53

Equipment support 1-84, 1-94

Erosion 1-103, 1-105, 1-106, 2-19, 2-40, 2-42, 2-56, 2-69, 7-13

Evacuation 1-18, 1-52, 1-76, 1-108, 13-8, 13-11, 13-27, 13-28, 13-44, 15-14, 15-40, 15-80

Evaporation 13-31, 15-32

Evaporative/adiabatic cooling 15-25, 15-27

Evaporative cooling 15-28, 15-30

Excavation 26, 1-109, 2-11, 2-16, 2-20, 2-38, 2-49, 16-7

Exclusion area 15, 1-69, 1-70, 9-5, 10-2, 13-67

Exemption 1-2, 1-3, 1-56

Exfiltration 2-38, 2-39, 8-1

Exhaust 1-40, 1-71, 1-72, 1-84, 1-85, 1-105, 2-68, 11-4, 11-5, 13-11, 13-33, 13-38, 13-45-48, 13-50, 13-51, 13-54, 13-55, 13-57, 13-61, 13-62, 13-75, 13-80, 13-81, 13-84, 13-85, 13-87, 13-90, 13- 91, 13-96, 13-97, 13-100, 13-104, 13-110-112, 13-114, 13-116, 13-120, 13-121, 13-125, 13-126, 14-2, 15-12, 15-26-31, 15-37, 15-39, 15-40, 15-45-50, 15-53, 15-72, 15-73, 15-76, 15-79, 15-80, 16-16

Existing building 26, 1-6, 1-21, 1-64, 1-66

Exit 1-68, 1-71, 1-73, 1-76, 2-51, 8-2, 8-6-8, 11-3, 13-8, 13-21-23, 13-29, 13-30, 13-69, 15-12, 15-22, 15-76, 16-15

Expansion joint 15, 7-2, 7-5, 7-12, 15-17, 15-60

Expansive soil 1-14, 1-96, 2-22

Explosion 12, 13, 16, 22, 28, 1-20, 1-39, 1-40, 1-54, 1-93, 1-98, 1-100, 2-5, 2-7, 2-66, 11-2, 13-44, 13-45, 13-48, 13-55, 13-61, 13-65, 13-67, 13-68, 13-72, 13-85, 13-88, 13-124, 15-9, 15-11-13, 15-50, 16-22, 16-27

Explosive 4, 9, 10, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 26, 27, 28, 1-5, 1-26, 1-27, 1-73, 1-93, 1-100, 1-101, 2-5, 2-18, 2-62, 9-2, 9-7, 11-4, 13-1-3, 13-16, 13-21, 13-22, 13-27, 13-44, 13-45, 13-62-69, 13-77, 13-88, 13-89, 13-93, 13-101, 13-113, 13-117, 13-119, 15-6, 15-13, 15-14, 15-23, 15-24, 15-48, 15-50-52, 15-70, 16-9, 16-20-23

Explosives activity 15, 16, 28, 13-64, 13-66, 13-68

Explosives bay 15, 28, 13-64, 13-66, 13-67, 15-13

Explosives building 15, 18, 19, 20, 26, 13-64, 13-66, 16-22

Explosives hazard classes 15, 13-65

Explosives hazard Class I 15

Explosives hazard Class II 16

Explosives hazard Class III 16

Explosives hazard Class IV 16

Explosives-only bay 13-66, 13-68, 13-69

Double-hyphen entries indicate inclusive pages e.g., "3-27-29" means page 3-27 through page 3-29. Entries for singular words can include plurals.

Exposure of the public 1-76, 1-97, 13-4, 13-5, 13-44, 13-52, 13-58, 13-70, 13-76, 13-82, 13-86, 13-92, 13-97, 13-105, 13-112, 13-116, 13-122, 15-45

Exterior 3, 1-29, 1-33, 1-57, 1-59, 1-78, 1-85-87, 1-92, 2-5, 2-31, 2-33, 2-52, 2-60, 2-62, 7-3-9, 7-12, 7-13, 8-1, 8-4-7, 10-2, 10-4, 11-2, 11-4, 13-13, 13-24, 13-26, 13-115, 15-1, 15-10, 15-11, 15-16, 15-54, 15-61, 15-68, 15-78, 16-3, 16-5, 16-6, 16-8, 16-14, 16-15, 16-24

Exterior communications 2-52, 16-24

Exterior electrical 2-52, 16-5, 16-6

Exterior insulation 3, 1-29, 7-8, 7-9

Exterior lighting 1-59, 2-52, 2-60, 16-8, 16-14, 16-15

Exterior utility 2-31, 2-33

External corrosion 16, 2-48

Eye wash 15-18

Facility authority 16

Facility boundary 16, 13-64

Facility criteria 1-99, 13-66

Facility location 15-55

Facility planning 2-2, 2-8

Facility siting 2-1, 2-2, 13-18, 13-19, 13-64, 15-69

Facility sizing 15-54

Facsimile 1-81, 2-8, 15-52

Facsimile center 1-81, 2-8, 15-52

Fail-safe 17, 13-45, 13-54, 15-18, 15-46, 15-81, 16-20

Fallout shelter 1-31, 1-54, 1-58

Fan 1-17, 1-21, 1-64, 1-67, 13-114, 15-28, 15-37-41, 15-43, 15-46, 15-47, 15-52, 15-53, 15-79-82, 16-12

Fault circuit interrupter 16-23

Fault zone 2-64

Federal Property Management Regulations 1-9

Feed area 13-87

Fence 16, 22, 23, 28, 1-69, 1-87, 2-13, 2-17, 2-31, 2-40, 2-53, 2-55, 2-57-60, 13-21, 13-24, 13-29, 16-10

Fencing 1-103, 1-104, 1-106, 1-107, 2-40, 2-53, 2-56, 2-57, 2-59, 2-60, 13-21

Field and laboratory report 2-9

Field element 17, 1-6, 1-7, 8-8, 13-17-20, 13-23, 13-24

Field log 2-9

Field notes 2-11, 2-12, 2-14

Field station 1-77

Filter 17, 1-19, 1-27, 1-48, 1-49, 11-2, 11-4, 13-30, 13-33, 13-40, 13-49, 13-50, 13-79-81, 13-83, 13-84, 13-88, 13-91, 13-95, 13-96, 13-100, 13-113-115, 15-13, 15-21, 15-37-40, 15-46-49, 15-53, 15-64, 15-71

Filtration 1-108, 13-7, 13-33, 13-34, 13-45, 13-46, 13-51, 13-54, 13-79, 13-80, 13-84, 13-95, 13-96, 13-113-115, 15-39, 15-40, 15-45-48, 15-50, 15-52, 15-53, 15-79

Final Safety Analysis Report (FSAR) 4, 1-54

Finish 1-13, 1-29, 1-36, 1-53, 1-55, 1-74, 2-10, 2-59, 7-4, 7-8, 7-9, 8-6, 9-1-3, 9-7, 10-4, 12-1-3, 13-33, 15-61

Finish system 1-29, 7-8, 7-9

Fire 3, 5, 9, 12, 13, 16, 17, 22, 23, 24, 1-11, 1-27, 1-30, 1-38-40, 1-48, 1-49, 1-52, 1-54-57, 1-70, 1-72, 1-74, 1-75, 1-79, 1-82, 1-84, 1-85, 1-87, 1-89, 1- 90, 1-98, 1-99, 1-108, 1-110, 2-5, 2-7, 2-8, 2-15-17, 2-23, 2-30, 2-31, 2-33-35, 2-52, 2-54, 2-55, 2-58, 2-66, 7-9, 8-1, 8-3, 8-7, 9-1, 10-3, 11-2-4, 12-1, 12-3, 13-3, 13-7, 13-8, 13-44, 13-45, 13-47, 13-48, 13-50, 13-53, 13-54, 13-59, 13-60, 13-63, 13-66, 13-68, 13-71, 13-77-79, 13-88, 13-93, 14-2, 15-2-17, 15-40, 15-52, 15-69, 15-71-73, 15-77, 15-80, 15-83, 16-2, 16-3, 16-6, 16-16, 16-18, 16-24, 16-27, 16-28

Fire alarm 1-84, 2-8, 2-17, 2-52, 15-8, 15-9, 15-14, 16-16, 16-24, 16-28

Fire and rescue facility 1-30, 2-30

Fire cutoff 1-72

Fire damper 15-13, 15-40

Fire department 1-56, 2-5, 15-3-5, 15-8

Fire detection 1-52, 11-4, 13-48, 15-4, 15-8, 15-9, 15-13, 15-14, 15-77, 16-18

Fire extinguisher 1-38, 10-3, 15-4, 15-8

Fire hose 15-4

Fire hydrant 2-15, 2-16, 2-31, 2-34, 2-35, 15-5

Fire main 2-31, 15-10

Fire protection 5, 12, 13, 17, 23, 24, 1-11, 1-27, 1-38, 1-39, 1-55-57, 1-79, 1-82, 1-85, 1-89, 2-31, 2-34, 2-55, 2-58, 8-1, 8-3, 9-1, 10-3, 11-2, 11-4, 13-3, 13-8, 13-47, 13-54, 13-60, 13-68, 13-77, 13-78, 13-88, 13-93, 15-2-6, 15-9-16, 15-40, 15-71, 15-77, 15-80

Fire protection design analysis 1-55

Double-hyphen entries indicate inclusive pages, e.g., “3-27-29” means page 3-27 through page 3-29. Entries for singular words can include plurals.

Fire pump 1-38, 2-23, 15-10

Fire-rated wall 1-56, 8-7

Fire resistance 1-48, 1-49, 1-55, 1-56, 1-75, 1-98, 7-9, 11-2, 12-3

Fire resistant 15-52

Fire retardant 9-1, 12-1

Fire station 1-85, 2-8, 2-30, 15-4

Fire suppression 13, 1-56, 1-75, 1-87, 1-108, 11-4, 13-3, 13-50, 13-53, 13-59, 13-66, 15-2-5, 15-11, 15-13

Fireplace 10-2

Firestopping 7-9, 11-3

Firing equipment 15-58, 15-72, 15-73, 15-75

Fissile material 4, 17, 1-5, 1-17, 1-42, 1-74, 13-2, 13-7, 13-8, 13-71, 13-77, 13-81, 13-86, 13-87, 13-91, 13-92, 13-98, 13-104, 13-106, 13-111, 13-117, 15-24, 15-45

Fitting 1-22, 15-10, 15-17, 15-36, 15-37, 15-58, 15-61, 15-66, 15-68, 16-2

Fixture 1-32, 2-62, 11-2, 11-3, 15-16-18, 16-2, 16-15

Flame 9-6, 15-1, 15-9, 15-38, 15-68, 15-80

Flame-actuated 15-9

Flammable 1-39, 1-73, 2-5, 2-32, 13-14, 13-45, 13-71, 13-77, 13-78, 13-88, 13-93, 15-7, 15-13, 15-15, 15-49, 16-20, 16-21, 16-23

Flanged joint 15-67

Flashing 7-1, 7-4, 7-5, 7-11, 7-12, 15-58

Flexibility 1-52, 1-53, 1-72, 1-75, 10-2, 12-3, 15-17, 16-14

Flexural strength 17

Flight 10, 2-28

Flood 3, 6, 13, 21, 23, 1-50, 1-54, 1-97, 1-99, 2-2, 2-6, 2-7, 2-29, 2-39-42, 2-44, 2-53, 2-66, 2-69, 16-27

Flooding 1-99, 2-6, 13-8, 15-49

Floodplain 1-8, 1-12, 2-2, 2-44, 2-51, 2-52, 2-64, 2-66

Floor 7, 26, 27, 29, 1-6, 1-19, 1-23, 1-26, 1-44, 1-45, 1-49, 1-56, 1-72, 1-74, 1-78, 1-82, 1-84, 1-86-89, 1-95, 1-96, 1-98, 2-7, 2-62, 3-4, 5-3, 7-1, 7-4-6, 7-8, 7-9, 8-1-3, 8-7, 9-1-3, 9-6, 9-7, 13-13, 13-25-27, 13-33, 13-47, 13-51, 13-53, 13-59, 13-62, 13-77, 13-82, 13-92, 13-98, 15-17, 15-19, 15-22, 15-60, 15-74, 15-77, 15-78, 16-3, 16-23

Floor area 1-74, 2-62, 13-26, 15-78

Floor covering 7, 1-23, 1-26, 1-45, 1-49, 1-82, 9-6, 9-7

Flow coefficient (C_v) 3, 15-81

Flow control 2-47, 15-83

Flow diagram 15-37

Flow switch 15-32

Flue 4, 1-90, 15-1, 15-72, 15-73, 15-75

Flue gas 4, 15-72, 15-73

Flue gas desulphurization (FGD) 4

Fluid 18, 22, 27, 1-29, 1-91, 1-94, 1-97, 1-100, 2-10, 13-6, 13-87, 13-118, 13-122, 13-123, 13-125, 13-126, 15-11, 15-22, 15-65, 15-66, 15-68

Fluid pressure 1-91

Fly ash 1-8

Foam 1-33, 1-38, 1-55, 8-4, 10-1, 10-3, 10-4, 15-7, 15-12, 15-68, 15-69

Foamite 2-34

Footing 9, 10, 1-15, 1-89, 2-21

Force main 17, 1-20, 2-37-39

Forced-flow 15-65

Forcible penetration 28

Forearm 13-9

Formboard 3-4

Formwork 1-15, 1-16, 1-95, 3-2

Foundation 9, 10, 17, 26, 27, 1-15, 1-20, 1-49, 1-89, 1-90, 1-94, 1-96, 2-1, 2-4, 2-9-11, 2-20-23, 2-37, 2-49, 2-68, 15-65, 16-9, 16-10

Fragment 1-28, 13-47, 13-49, 13-64-68

Frame 1-18, 1-45, 1-47, 1-75, 1-87, 1-88, 1-92, 7-8, 7-10, 8-1, 8-3, 8-4, 8-6, 8-7, 9-3, 16-25

Framing 5, 7, 1-36, 1-47, 1-74, 1-89, 1-91, 1-95, 8-1, 9-3

Freeboard 17, 2-42, 2-48

Frost 1-96, 2-11, 2-49

Fuel 7, 17, 20, 21, 28, 1-7-9, 1-18, 1-31, 1-39, 1-40, 1-42, 1-61, 1-65, 1-79, 1-86, 1-106, 2-31, 2-53, 5-2, 13-18, 13-44, 13-55, 13-57, 13-60, 13-76, 13-81, 13-82, 13-85, 13-86, 13-91, 13-111, 13-112, 13-122, 13-124, 15-1, 15-5, 15-6, 15-9, 15-12, 15-30, 15-35, 15-55, 15-58, 15-59, 15-71-73

Fuel gas 1-39, 2-31

Fuel oil 1-40, 15-35

Double-hyphen entries indicate inclusive pages, e.g., "3-27-29" means page 3-27 through page 3-29. Entries for singular words can include plurals.

Fuel selection 1-31, 15-72

Fume 9, 2-7, 11-1, 11-4, 13-113, 13-114, 13-119, 15-28, 15-29, 15-71, 15-72, 16-27

Furnishing 1-90, 12-1, 12-2

Furniture 1-53, 1-76, 10-4, 12-2, 12-3, 13-37

Fusion 1-5, 13-2, 13-116, 13-121-126, 15-17

Galvanized 2-59, 8-6, 15-17

Garbage 25, 15-29

Gas 1, 2, 4, 5, 15, 1-20, 1-25, 1-27, 1-39, 1-40, 1-42, 1-67, 1-72, 1-73, 1-94, 1-105, 2-1, 2-4, 2-5, 2-10, 2-11, 2-15, 2-17, 2-31, 2-45, 2-62, 2-65, 11-2, 11-4, 13-13, 13-15, 13-39, 13-45-48, 13-50-52, 13-57, 13-58, 13-62, 13-69-74, 13-77, 13-79, 13-80, 13-87, 13-89, 13-91, 13-93-96, 13-102, 13-107, 13-109, 13-111-113, 13-116-121, 13-126, 15-7, 15-12, 15-14, 15-15, 15-28, 15-29, 15-32, 15-35, 15-39, 15-42, 15-44, 15-48-50, 15-53, 15-55, 15-57, 15-58, 15-63, 15-64, 15-68, 15-69, 15- 71-73, 15-75, 15-76, 15-80, 16-16, 16-17, 16-20, 16-21, 16-23

Gas-cleaning 15-75

Gas-fired 15-32, 15-35, 15-58, 15-72, 15-80

Gas pressure 1-94, 13-69, 15-80

Gaseous diffusion 13-70, 13-72, 13-73, 15-14

Gasket 15-17, 15-68

Gate 1-68, 1-72, 2-34, 2-35, 2-57-60, 13-21

Gate grounding 2-60

General Services Administratration (GSA) 4, 1-6, 1-7, 1-13, 1-87, 13-26

Generating facility 15-55

Generation 14, 20, 27, 1-42, 1-71, 1-105, 1-109, 2-47, 2-50, 2-52, 11-3, 13-56, 15-1, 15-18, 15-34, 15-35, 15-54, 15-56-58, 15-69, 15-75, 16-5

Generator 29, 1-8, 1-31, 1-38, 1-79, 1-84, 1-86, 2-23, 13-46, 15-32, 15-53, 15-56, 16-11, 16-17, 16-18, 16-24

Geographic 2-40, 2-41, 2-64, 15-69

Geologic 1-7, 2-1, 2-4, 2-19, 2-33, 2-37, 2-41, 2-43, 2-64, 13-107-110

Geometry 1-14, 2-27, 2-56, 13-7, 13-8, 13-31, 13-45, 13-49, 13-50, 13-52, 13-53, 13-57, 13-59, 13-60, 13-71, 13-73, 13-74, 13-77, 13-82, 13-86, 13- 91-94, 13-98, 13-104, 13-106, 13-111, 15-22

Glass 4, 1-14, 1-17, 1-23, 1-31, 1-46, 1-67, 1-85, 8-1-4, 8-6, 8-8, 11-3, 13-31, 15-36, 15-40, 15-48, 15-53

Glazing 1-31, 8-1, 8-2, 8-8

Glove box 11, 15, 11-3, 11-5, 13-46-48, 13-78, 13-79, 13-93, 13-95, 13-112-114, 13-118, 13-119

Grade 17, 26, 1-74, 1-96, 2-9, 2-11, 2-22, 2-25-27, 2-54, 2-55, 2-61, 7-1-7, 7-13, 13-70, 13-73, 15-17, 16-5, 16-7

Grade beam 17, 2-22

Graphic 1-28, 2-19, 10-2, 13-39

Gravity-flow 1-72

Grille 1-88, 10-1, 15-41

Ground 13, 17, 24, 25, 26, 1-58, 1-70, 1-99, 1-106, 2-6, 2-12, 2-14, 2-17, 2-26, 2-28, 2-30, 2-32, 2-34, 2-59, 2-62, 2-69, 2-70, 7-2, 7-5, 13-16, 13-102, 13-108, 15-1, 15-52, 15-69, 16-3, 16-5, 16-7, 16-9-11, 16-22, 16-23

Ground cover 2-69, 2-70

Ground distance 2-12, 2-14

Ground fault 16-23

Ground system 16-10

Grounding 1-27, 1-34, 1-108, 2-26, 2-58-60, 16-3, 16-4, 16-8, 16-10, 16-22, 16-23

Groundwater 9, 20, 25, 1-20, 1-94, 2-6, 2-9, 2-10, 2-19, 2-20, 2-35, 2-36, 2-38, 2-45-50, 2-64, 2-66, 2-67, 13-16, 13-98, 13-107, 13-108, 13-110

Groundwater pressures 1-94

Groundwater resources 2-66

Grout 4-1, 4-2

Guard 20, 25, 29, 1-69, 1-83, 2-12, 2-53, 2-60-62, 8-3, 13-25, 13-26, 13-28, 13-33

Guard station 2-60, 13-28, 13-33

Guard tower 2-61, 2-62, 13-25, 13-26

Guardrail 2-25, 2-56, 7-10

Gutter 2-16, 2-26, 2-27, 2-56, 7-12, 7-13, 15-23

Gypsum 4, 1-23, 1-33, 3-4, 9-4

Gypsum board 1-23, 9-4

Hail 2-2

Halogenated 17, 15-12, 15-14

Double-hyphen entries indicate inclusive pages, e.g., “3-27-29” means page 3-27 through page 3-29. Entries for singular words can include plurals.

Halon 1-38, 13-48, 15-4, 15-7, 15-12, 16-18

Hand and forearm protection 13-9

Handicapped 1-6, 1-7, 1-57, 1-76, 1-77, 2-26, 2-54, 2-55, 8-1, 10-5, 13-44, 14-2, 14-3, 15-16

Handling system 2-45, 13-50, 13-55, 13-60, 13-118, 14-1, 15-28, 15-31, 15-37, 15-39, 15-41, 15-58, 15-59, 15-74, 15-78-81

Hand-off-automatic (HOA) 4, 15-77

Hardware 19, 1-18, 1-76, 1-87, 1-88, 2-58-60, 8-1-3, 8-7, 12-2, 13-25, 15-39

Hazard 6, 15, 16, 21, 25, 1-35, 1-36, 1-53, 1-54, 1-56-58, 1-71, 1-73, 1-74, 1-76, 1-77, 1-87, 1-92, 1-93, 1-97-99, 2-2, 2-5, 2-29, 2-55, 2-59, 9-2, 9-7, 12-1, 13-3-5, 13-8, 13-9, 13-12, 13-36, 13-39, 13-44, 13-47, 13-48, 13-54, 13-58, 13-60, 13-63-66, 13-68, 13-69, 13-71, 13-77, 13-79, 13-80, 13- 88-90, 13-96, 13-101, 13-107, 13-110, 13-112, 13-117, 13-121, 13-122, 15-3-7, 15-9, 15-12, 15-13, 15-50, 15-70, 16-7, 16-10, 16-21, 16-28

Hazard class 15, 16, 13-63-66

Hazard model 1-36, 1-92, 1-93, 1-98, 1-99

Hazardous 11, 12, 17, 1-8, 1-9, 1-11, 1-12, 1-54, 1-56, 1-57, 1-71-73, 1-76, 1-77, 1-98, 2-1, 2-5, 2-7, 2-18, 2-44, 2-45, 2-47-50, 2-53, 2-63-67, 8-2, 8-5, 9-1, 11-1, 11-3, 13-3, 13-4, 13-8, 13-10, 13-12-16, 13-33, 13-34, 13-39, 13-44-49, 13-52-54, 13-58, 13-59, 13-63-68, 13-71, 13-78-80, 13- 87, 13-89-91, 13-93-96, 13-112, 13-114, 13-117, 13-123-125, 14-1, 14-2, 15-3, 15-13, 15-15, 15-22, 15-23, 15-28, 15-29, 15-40, 15-42, 15-44-48, 15-50, 15-75, 15-76, 16-2, 16-9, 16-16, 16-18, 16-20, 16-21, 16-27

Hazardous area 1-56, 1-57, 1-72, 1-76, 1-77, 2-7, 2-53, 13-44, 13-53, 13-59, 14-2

Hazardous fragment 13-64-68

Hazardous location 15-15, 16-20, 16-21, 16-27

Hazardous material 11, 12, 17, 1-11, 1-54, 1-71-73, 1-76, 1-98, 2-1, 2-5, 2-45, 2-47, 2-50, 9-1, 11-1, 11-3, 13-3, 13-4, 13-8, 13-10, 13-12, 13-13, 13-33, 13-34, 13-45-49, 13-54, 13-63, 13-78, 13-80, 13-87, 13-89, 13-90, 13- 93, 13-94, 13-96, 13-112, 13-114, 13-117, 13-123-125, 14-1, 15-3, 15-23, 15-40, 15-42, 15-44-48, 15-50, 15-76, 16-9

Hazardous waste 1-8, 1-9, 1-11, 1-12, 2-18, 2-47-49, 2-66, 13-14, 13-15, 13-91, 15-75

Headquarters 12, 17, 1-1-3, 1-47, 1-49, 1-67, 1-79, 1-81, 1-84, 1-92, 1-98, 2-9, 2-56, 10-3, 13-17-19, 16-13, 16-27

Health 6, 8, 14, 17, 23, 25, 29, 1-3, 1-5, 1-8, 1-11, 1-27, 1-33, 1-34, 1-40, 1-53, 1-60, 1-66, 1-68, 1-71, 1-73-75, 1-77, 1-78, 1-97, 2-1, 2-4, 2-33, 2-43, 9-2, 12-1, 13-2, 13-3, 13-5, 13-9, 13-18, 13-28, 13-31, 13-97, 13-105, 13-124, 15-2, 15-24-26, 15-29, 15-30, 15-77, 16-14-16

Health physics 1-71, 13-9, 13-28

Heat exchanger 1-71, 13-83, 15-20, 15-31, 15-34, 15-43, 15-68, 15-80, 15-81

Heat gain 1-63, 1-64, 15-25, 15-31, 15-33, 15-52, 15-53

Heat generation 1-42, 11-3, 15-34, 15-35, 15-54

Heat loss 1-63, 1-64, 2-68, 15-25, 15-54

Heat pipe 15-31

Heat-actuated detector 15-9

Heating 1, 4, 5, 16, 1-19, 1-21, 1-22, 1-31, 1-36, 1-59, 1-61-67, 1-71, 1-90, 2-15, 2-68, 9-1, 13-7, 13-27, 13-45, 13-52, 13-58, 13-72, 13-86, 13-94, 13-98, 13-106, 15-16, 15-18, 15-22, 15-25-28, 15-30, 15-31, 15-33-36, 15-38, 15-41, 15-43, 15-52-54, 15-57-59, 15-65, 15-77-79, 15-81-83, 16-28

Heating, ventilating and air conditioning (HVAC) 4, 1-46, 1-52, 1-61, 1-63-65, 1-71, 1-74, 1-76, 1-108, 13-3, 15-1, 15-14, 15-25-27, 15-30, 15-31, 15-40, 15-42, 15- 53, 15-62, 15-77, 15-78, 16-19

Helicopter 2-28

Heliport 1-30, 1-40, 2-28-30

Hertz, frequency (Hz) 4, 1-18

High-expansion foam 15-12

High Explosives (HE) 4, 16, 17, 19, 1-33, 2-50, 9-7, 13-21, 13-65, 13-68, 13-69

High explosives-plutonium (HEPu) 4, 13-65, 13-68

High frequency (HF) 4, 8

High intensity discharge (HID) 4, 2-62, 16-15

High-resistivity 2-60

High temperature 4, 1-31, 13-73, 15-32, 15-34, 16-25

High temperature water (HTW) 4, 1-31, 15-32, 15-34, 15-35, 15-54, 15-56-58, 15-60, 15-61, 15-56-58, 15-60

High-voltage 2-7, 2-8, 2-59, 13-122

High-efficiency particulate air (HEPA) 4, 17, 11-4, 13-7, 13-11, 13-45, 13-54, 13-79, 13-80, 13-84, 13-95, 13-96, 13-113-115, 15-39, 15-40, 15-46-49, 15-52

Higher standard of protection 17, 15-2

High-Level Waste (HLW) 4, 17, 20, 28, 2-4, 13-14, 13-97, 13-107

Highway 1, 4, 19, 22, 23, 27, 1-14, 1-18, 1-25, 1-44, 1-90-92, 1-94-96, 2-5, 2-23-25, 2-28, 2-53, 2-55, 2-57, 3-1, 3-2, 4-1, 5-2, 5-3, 6-1, 16-15

Historic 5, 1-8, 1-9, 1-97, 1-99, 1-104, 2-1, 2-40

Double-hyphen entries indicate inclusive pages, e.g., “3-27-29” means page 3-27 through page 3-29. Entries for singular words can include plurals.

Holdup 17, 13-30, 13-32, 13-50, 13-78, 13-91, 13-104, 13-111, 13-114, 15-16

Hood 9, 1-71, 11-1, 11-2, 11-4, 11-5, 12-3, 13-47, 13-112-114, 13-118, 13-119, 15-47

Horizontal control 1-16, 1-108, 2-12-14

Horsepower (hp) 2, 4, 15-36, 15-37, 15-81, 15-82, 16-12, 16-13

Hose 1-38, 15-4, 15-5, 15-8, 15-11, 15-19, 16-21

Hose bibb 15-19

Hot cell 15, 13-45, 13-112-114, 15-46

Hot line 18, 1-109

Hot water 1-31, 1-64, 15-18, 15-31, 15-33-36, 15-38, 15-55, 15-81, 15-82

Hot weather concreting 1-15, 3-3

Human dimension 13-37

Human factor 18, 1-29, 1-35, 1-36, 13-34-37

Human factors engineering 18, 13-34-37

Humidification 15-25, 15-26

Humidity 16, 30, 1-65, 2-6, 7-4, 7-6, 9-5, 13-6, 13-11, 13-31, 13-37, 15-25-27, 15-77-79

Hydrant 2-15, 2-16, 2-31, 2-34, 2-35, 15-3, 15-5, 15-10, 15-11, 15-19

Hydraulic 4, 13, 17, 18, 1-20, 2-10, 2-33, 2-37, 2-42, 2-66, 13-21, 13-107, 13-118, 15-6, 15-10, 15-19

Hydraulic structure 13, 17, 18, 1-20

Hydrogen fluoride (HF) 4, 13-72, 13-94, 15-14, 15-15, 16-27

Hydrology 24, 1-50, 2-6, 2-40, 2-41, 2-69

Hydronic 1-13, 15-35

Identifying device 10-2, 13-43

IHE weapon 18, 13-68

Illumination 4, 1-69, 1-70, 2-62, 2-63, 10-4, 11-2, 12-1-3, 13-26, 13-38, 16-14, 16-15

Impervious 18, 13-103

Improved risk 17, 18, 1-55, 1-56, 15-2, 15-4, 15-13, 15-60, 15-71, 15-72

Impurity 13-72, 13-73

In-process or in-use material 19, 13-82

In-situ 19, 13-107, 15-73

Incinerator 13-32, 15-72, 15-74, 15-75

Indoor air 1-21, 1-60, 2-1, 2-4, 9-1, 15-28, 15-29

Industrial 1, 18, 25, 1-9, 1-11, 1-14, 1-18-20, 1-25, 1-28, 1-34, 1-38, 1-41, 1-46, 1-48, 1-57, 1-59, 1-73, 1-105, 2-5, 2-24, 2-33-37, 2-44, 2-46, 2-47, 2-50, 7-10, 8-4, 8-5, 9-4-6, 11-1, 11-4, 11-5, 12-2, 13-3, 13-5, 13-14, 13-16, 13-56, 15-9, 15-24, 15-29, 15-30, 15-37-40, 15-74, 15-75, 16-6, 16-28

Industrial ventilation 1-14, 11-1, 11-4, 11-5, 15-29, 15-30, 15-37-40, 15-74, 15-75

Industrial waste 1-105, 2-47, 2-50, 13-56

Industrial wastewater 1-20, 1-57, 2-36, 2-37, 2-44, 2-46, 2-47, 2-50, 13-14, 13-16

Industrial water 1-28, 2-35, 2-36, 2-46

Inert gas 13-72, 13-113, 15-12, 15-15, 15-58

Infiltration 1-63, 2-38, 2-39, 2-50, 8-1, 15-26, 15-29, 15-53, 15-61

Ingot 13-74

Ingress 18, 2-58, 2-61, 2-63, 13-54, 13-60

Inhabited building distance 18, 28, 13-64, 16-22

Initiation stimulus 15, 18

Injury 1-53, 1-77, 11-4, 13-45, 13-63, 13-67, 13-68, 15-69

Inner vessel 15-66

Insensitive high explosives (IHE) 4, 16, 18, 19, 13-65, 13-68, 13-69

Inside design temperature 15-25, 15-26

Inside diameter (ID) 4, 1-79, 1-107, 13-23

Inspection 16, 18, 21, 23, 1-11, 1-58, 1-70, 1-74, 1-102, 1-107, 1-109, 2-9, 2-24, 2-49, 2-50, 13-6, 13-21, 13-22, 13-34, 13-53, 13-56, 13-58, 13-72, 13-74, 13-112, 15-21, 15-23, 15-46, 15-49-51, 15-55, 15-67

Instrumentation 1-18, 1-42, 1-108, 13-6, 13-31-33, 13-37, 13-72, 13-73, 13-83, 13-99, 13-107, 15-20, 15-22, 15-44, 15-46, 15-49, 15-60, 15-66, 15-74, 15-83, 16-10, 16-17-21

Insulation 2, 3, 7, 1-29, 1-33, 1-48, 7-6-10, 13-94, 15-1, 15-19, 15-35, 15-41, 15-60, 15-61, 15-66, 15-68-70

Interface 15, 16, 19, 1-62, 1-101, 9-2, 11-4, 13-32, 13-34, 13-36, 15-11, 15-47, 15-80, 15-83, 16-25, 16-26

Interfacing 15-34, 15-47, 15-83

Interior communications 2-53, 16-27

Double-hyphen entries indicate inclusive pages, e.g., “3-27-29” means page 3-27 through page 3-29. Entries for singular words can include plurals.

Interior lighting 12-2, 12-3, 13-38, 16-15

Interlock 1-57, 1-76, 13-29, 13-53, 13-59, 13-73, 13-78, 13-93, 15-32, 15-65, 15-77, 15-80, 16-18, 16-20

Intermediate metal conduit (IMC) 4, 16-2

Internal pressurization 1-100

Internal shock 1-93

Internal water 15-59

Interstitial space 1-53

Intraline separation 19, 26

Intrusion alarm system (IAS) 4, 19, 29, 1-86, 2-54, 2-55, 2-57, 2-58, 2-60, 9-4, 10-2, 13-20, 13-23, 13-24

Intrusion detection 4, 1-47, 1-70, 2-27, 2-59, 13-20, 13-22, 13-23, 14-1

Intrusion detection and assessment (IDA) 4, 2-58, 2-59

Intrusion detection system (IDS) 4, 1-70, 13-24, 16-24

Inventory 7, 18, 21, 24, 1-74, 2-68, 13-29, 13-30, 13-32, 13-53, 13-54, 13-56, 13-58, 13-59, 13-71, 13-78, 13-87, 13-101-103, 13-116, 13-122, 13-124, 15-15, 15-62

Inverted siphon 19, 2-39

Ion exchange 19, 15-12

Ionizing radiation 13-10

Irradiated fissile material (IFM) 4, 1-5, 1-74, 13-2, 13-81-85, 15-24

Irradiated fissile material storage facility (IFMSF) 4, 1-5, 13-2, 13-81-86, 15-24

Irrigation 2-33, 2-45, 2-68-70

Isolation 8, 17, 19, 28, 1-73, 1-94, 1-96, 5-3, 13-38, 13-77, 13-93, 13-99, 13-105, 13-113, 15-14, 15-15, 15-17, 15-53, 15-64, 16-11

Isolation zone 19

Jacket 13-7, 13-8, 13-45, 13-83, 13-86, 13-98, 13-106, 15-24, 15-61, 15-66

Joining method 15-67

Joint 11, 15, 20, 1-15, 1-20, 1-27, 1-96, 1-99, 2-6, 2-24, 2-28, 2-32, 2-35, 2-38, 2-39, 2-49, 4-2, 7-2, 7-3, 7-5-7, 7-12, 7-13, 9-7, 13-33, 13-51, 13-68, 13-90, 15-17, 15-23, 15-41, 15-60, 15-61, 15-67, 16-6, 16-24, 16-27

Joint bar 2-24

Joint explosive 13-68

Joint frequency distribution 20, 2-6

Joint use 16-6, 16-24, 16-27

Joist 7, -46, 5-3

Karst 20, 2-64

Kilo Pascal (kPa) 4

Label 21, 8-1, 8-3, 13-39, 13-43, 16-1

Labeling 13-34, 13-40, 13-42, 13-43,

Laboratory 1, 2, 5, 6, 7, 8, 18, 19, 21, 1-4, 1-17, 1-33, 1-35, 1-39, 1-46, 1-48, 1-56, 1-69, 1-71, 1-110, 2-7, 2-9, 2-10, 7-9, 8-1, 8-3, 9-2, 10-2-4, 12-3, 13-2, 13-30, 13-63, 13-82, 13-112-116, 15-27, 15-29, 15-30, 15-32, 15-59, 16-20

Laminated glass 8-4

Land application 20, 2-45

Landfill 20, 25, 1-105, 2-47, 15-75

Landscape 1-106, 2-45, 2-68, 2-70, 9-5, 12-2

Landscaping 16, 1-104, 2-5, 2-17, 2-19, 2-27, 2-56, 2-68, 2-69, 9-5

Lath 5, 1-36, 7-8, 9-4

Layout 1-53, 1-71, 1-73, 1-74, 1-76, 1-81, 1-84-86, 2-23, 2-27, 2-28, 2-30, 2-34, 2-37, 13-8, 13-9, 13-34, 13-37, 13-53, 13-58, 13-59

Leachate 20, 25, 2-65

Leakage 14, 1-46, 1-60, 1-61, 1-108, 2-50, 7-1, 7-5, 13-13, 13-14, 13-45, 13-49, 13-56, 13-72, 13-73, 13-81, 13-83, 13-86, 13-87, 13-90, 13-94, 13-98-102, 13-106, 13-118, 13-120, 13-124, 13-125, 15-21, 15-40, 15-68, 15-70, 15-77, 15-79

Liability 2, 1-9

Life-cycle cost (LCC) 5, 20, 1-53, 1-58-63, 1-65-68, 1-71, 2-44, 2-47, 2-64, 9-1, 10-2, 12-1, 15-18, 15-19, 15-27, 15-31, 15-32, 15-35, 15-37, 15-52, 15-55-57, 15-81, 15-83, 16-17, 16-28

Lift 17, 13-31, 14-1, 14-3, 15-60, 15-74

Liftstation 2-37

Lighting 16, 1-18, 1-35, 1-52, 1-59, 1-60, 1-62-67, 1-69, 1-70, 1-76, 2-17, 2-19, 2-52, 2-55, 2-56, 2-60, 2-62, 2-63, 11-3, 12-2, 12-3, 13-13, 13-26, 13-29, 13-32, 13-34, 13-38, 13-40, 15-77, 15-83, 16-2, 16-3, 16-8, 16-9, 16-11, 16-14, 16-15

Lightning 1-39, 1-99, 1-109, 2-2, 2-52, 13-69, 16-9, 16-22, 16-23

Double-hyphen entries indicate reclusive pages, e.g., "3-27-29" means page 3-27 through page 3-29. Entries for singular words can include plurals.

Limited area 20, 1-69, 1-70, 1-80

Liquid contaminant 1-106

Liquid cooler 1-21, 15-33

Liquid crystal display (LCD) 5, 13-40,

Liquid effluent 2-51, 13-50, 13-118, 15-59

Liquid nitrogen 13-31, 15-69, 15-70

Liquid radioactive waste 2-51, 13-50, 13-62, 13-75, 13-81, 13-85, 13-91, 13-96, 13-104, 13-111, 13-115, 13-116, 13-120

Liquid transfer 13-33

Liquid waste 7, 10, 17, 1-5, 1-42, 2-50, 13-2, 13-33, 13-50, 13-56, 13-61, 13-62, 13-75, 13-81, 13-85, 13-91, 13-96-104, 13-111, 13-115, 13-120, 13-126, 15-24

Liquified petroleum gas (LPG) 5, 2-31, 16-17

Live load psf - pounds per square foot (LL) 5

Live load 5, 11, 20, 1-90, 1-91, 7-2, 7-5

Load 3, 5, 11, 12, 20, 24, 27, 28, 29, 1-18, 1-22, 1-31, 1-37, 1-46, 1-60, 1-61, 1-63, 1-64, 1-74, 1-77, 1-86, 1-90-100, 1-109, 1-110, 2-9, 2-21, 2-49, 2-61, 4-2, 5-3, 7-2, 7-5, 7-10, 7-12, 8-3, 9-3, 11-1, 13-9, 13-36, 13-68, 13-71, 13-84, 15-5, 15-20, 15-25-28, 15-30-32, 15-34, 15-35, 15-44, 15-49, 15-52, 15-54-56, 15-59, 15-60, 15-67, 15-81-83, 16-1, 16-5, 16-6, 16-8-10, 16-12, 16-16-18

Load combination 1-100

Load control 15-35, 15-82, 15-83

Load factor 20, 1-91, 15-54

Loading 9, 20, 27, 28, 1-28, 1-71, 1-74, 1-90-94, 1-97, 1-98, 2-4, 2-6, 2-23, 2-54, 2-68, 5-1, 7-10, 7-13, 11-2-4, 13-28, 13-53, 13-56, 13-59, 13-67, 13-84, 13-88, 13-116, 15-9, 15-13, 15-22, 15-33, 15-39, 15-46, 15-47, 15-50, 15-55, 15-66, 16-12

Lobe compressor 15-63

Location 14, 15, 19, 20, 22, 24, 29, 1-6, 1-51, 1-58, 1-61, 1-71-74, 1-76, 1-77, 1-79, 1-90, 1-98, 1-104, 1-108, 2-2, 2-4, 2-5, 2-9, 2-10, 2-12, 2-14-17, 2-24, 2-26, 2-27, 2-29, 2-31, 2-33, 2-39, 2-40, 2-42, 2-43, 2-45, 2-54, 2- 55, 2-57, 2-59, 2-61, 2-64, 2-67-69, 7-12, 11-1, 11-2, 11-4, 11-5, 13-8, 13-12, 13-17, 13-23-25, 13-28-31, 13-33, 13-39, 13-41-43, 13-45, 13-48-50, 13-53, 13-56, 13-59, 13-63, 13-64, 13-69, 13- 78, 13-79, 13-88, 13-89, 13-95, 13-101, 13-118, 13-123, 13-124, 14-3, 15-4, 15-8, 15-10, 15-11, 15-13-15, 15-17, 15-19, 15-22, 15-26-28, 15-33, 15-35, 15-37, 15-39, 15-41, 15-42, 15-45, 15-51, 15-52, 15- 55, 15-77, 16-2, 16-3, 16-6, 16-10, 16-12, 16-15, 16-20-24, 16-27

Locker 10-3

Loss limitation 1-74, 1-75, 13-53, 13-59

Louver 1-23, 1-48, 10-1

Low-level liquid 13-100, 13-101, 13-103, 13-104

Low-Level Waste (LLW) 5, 20, 13-14, 13-108, 13-110, 13-111

Lubricant 6, 1-82, 1-106, 2-31, 15-64

Magazine 20, 26, 9-2, 13-67, 13-68, 15-13, 16-21

Magazine separation 20, 13-67

Maintainability 1-35, 13-6, 13-35, 13-42

Maintenance 6, 17, 18, 24, 27, 29, 1-2, 1-39, 1-55, 1-57, 1-58, 1-62, 1-65, 1-72-75, 1-81, 1-82, 1-84-86, 1-102, 1-109, 2-3, 2-5, 2-7, 2-8, 2-17, 2-24, 2-28, 2-34, 2-35, 2-37, 2-42, 2-44, 2-55, 2-56, 2-60, 2-62, 2-65-70, 3-5, 7-10, 7-13, 8-3, 9-5, 11-2, 11-3, 13-6, 13-7, 13-9, 13-11, 13-13, 13-34, 13-35, 13-37, 13-39, 13-40, 13-42, 13-45, 13-47, 13-52, 13-53, 13-58, 13-62, 13-70, 13-72, 13- 74, 13-85, 13-88, 13-101, 13-110, 13-113, 13-114, 13-117, 13-123, 15-4, 15-17, 15-19, 15-21, 15-25, 15-33, 15-35, 15-37, 15-40, 15-44-49, 15-55, 15-59, 15-61, 15-62, 15-64, 15-69, 16-1, 16-6, 16-7, 16-9

Makeup air 15-28, 15-30, 15-50, 15-53

Makeup water 13-82, 15-24, 15-59, 15-61

Manhole 2-12, 2-15, 2-17, 15-61, 16-7, 16-24

Manpower 1-29, 2-47

Map 1-84, 1-107, 2-10, 2-11

Masonry 5, 29, 1-15, 1-22, 1-24, 1-37, 1-38, 1-82, 1-95, 4-1, 4-2, 7-1, 7-2, 7-4, 7-5, 7-7, 9-3, 9-7, 16-2

Mass concrete 20, 1-15, 3-2, 3-5

Mast 1-86, 5-2, 16-27

Master safeguards 5, 1-11

Master Safeguards and Security Agreement (MSSA) 5, 1-68, 1-70, 2-56, 2-59, 13-17, 13-19, 13-20, 13-22, 13-26

MASTERFORMAT 1-3, 1-5, 13-1

Mat 1-15, 2-22, 12-2, 12-3, 14-2

Material access 5, 20, 23, 1-68-70, 13-18, 13-20, 13-22, 13-23, 13-27

Material access area (MAA) 5, 20, 23, 1-68-70, 13-18, 13-20, 13-22, 13-23, 13-27-30, 13-33, 13-46

Material balance area (MBA) 5, 21, 13-28-32

Material control and accountability (MC&A) 5, 13-16, 13-17, 13-26, 13-27, 13-54

Double-hyphen entries indicate inclusive pages, e.g., “3-27-29” means page 3-27 through page 3-29. Entries for singular words can include plurals.

Material safeguard 13-9, 13-16, 13-21, 13-69, 13-121, 13-127

Maximal effective pressure 21, 22, 13-67. Maximum possible fire loss 1-75

Maximum possible fire loss 13-53, 13-59, 15-2, 15-3

Maximum probable flood 21

Mechanical 2, 12, 13, 14, 15, 1-3, 1-4, 1-19, 1-21, 1-22, 1-24, 1-33, 1-53, 1-60, 1-64, 1-66, 1-69, 1-70, 1-96, 2-8, 7-6, 7-7, 7-9, 8-6, 10-1, 12-1, 13-1, 13-6, 13-30, 13-40, 13-52, 13-57, 13-82, 13-87, 15-1, 15-11, 15-16, 15-19, 15-22, 15-28, 15-30, 15-42, 15-51, 15-58, 15-62, 15-73, 15-79, 16-3, 16-9, 16-10

Mechanical insulation 15-1, 15-19

Medical 1-10, 1-77, 9-2, 9-3

Medical facility 1-77

Membrane 10, 28, 1-20, 1-75, 7-3-5, 7-9, 7-11

Membrane roofing 7-9, 7-11

Metal 2, 4, 5, 7, 10, 11, 16, 1-23, 1-33, 1-36, 1-46, 1-59, 1-61, 1-87, 2-13-15, 2-32, 2-48, 4-2, 5-1, 5-3, 7-7, 7-11, 7-12, 8-2, 8-4-7, 9-3, 9-5, 9-7, 13-22, 13-27, 13-33, 13-48, 13-49, 13-53, 13-59, 13-72, 13-73, 13-76, 13-78-80, 13-92, 13-93, 13-118, 13-121, 13-126, 15-2, 15-6, 15-13, 15-15, 15-16, 15-23, 15-33, 15-40, 15-51, 15-53, 15-61, 15-69, 16-2, 16-3, 16-15, 16-25

Metal support 9-3

Metallic tubing 3, 16-2

Meteorological 20, 21, 2-3, 2-6, 13-11

Meteorology 2-6, 15-73

Meter 1-82, 13-40, 16-12, 16-22

Metering 1-67, 1-68, 15-83, 16-8, 16-12

Methyl methacrylate 3-4

Miles, total level route (MI) 1-15, 5

Milli roentgen equivalent man (mrem) 5, 13-105

Milli roentgen/hour (mr/h) 5, 13-73

Mine 2-4

Minimum fragment distance 13-64

Minimum reinforcing ratio (p) 6, 7, 1-15, 1-23, 1-25-29, 1-32, 1-33, 1-35-37, 1-45, 1-46, 2-20, 2-38, 8-7, 15-16, 15-69

Missile 1-92, 1-97, 1-98, 1-100, 13-55, 13-61, 13-65-68, 13-85, 13-115, 13-119

Mixed-use 13-4

Mixed waste 1-11, 1-71, 13-14, 13-16, 13-105

Mixing 1-15, 2-50, 3-2, 3-3, 3-5, 4-2, 13-14, 13-30, 13-50, 13-56, 13-71, 13-72, 15-37, 15-38, 15-51, 15-58, 15-59, 15-72

Modular 10, 1-1, 1-61, 2-44, 11-3, 12-3, 13-33, 13-34, 13-52, 13-58, 13-87, 15-54

Modular building 1-1, 1-61

Modular construction 11-3, 13-52, 13-58

Modularity 1-53

Moisture 10, 1-96, 2-22, 2-41, 4-1, 7-1, 7-7, 8-4, 9-5, 10-1, 10-3, 10-4, 11-4, 13-11, 13-78, 15-14, 15-15, 15-38, 15-40, 15-48, 15-69, 16-10

Monitoring 2, 3, 12, 15, 23, 1-11, 1-18, 1-20, 1-67, 1-71, 1-73, 1-76, 2-45, 2-49, 2-50, 2-66, 2-67, 13-4, 13-7-11, 13-13, 13-15, 13-16, 13-18, 13-25-28, 13-32, 13-45, 13-48-50, 13-56, 13-57, 13-61, 13-62, 13-69, 13-72, 13-75, 13-80, 13-81, 13-85, 13-91, 13-96, 13-97, 13-99, 13-100, 13-102-104, 13-107, 13-111, 13-114-117, 13-120, 13-121, 13-123, 13-126, 15-22, 15-42, 15-46, 15-52, 15-60, 15-74-77, 16-19

Monitoring and control system 3, 15, 1-20

Monument 1, 2-12 15

Monumentation 21, 2-12

Mortar 22, 1-15, 1-22, 3-4, 4-1, 4-2, 7-2

Motor 1-38, 1-49, 2-58, 13-7, 13-71, 13-73, 15-32, 15-36-38, 15-52, 15-59, 16-9, 16-11-13

Motor control 16-12, 16-13

Mountainous region 2-41

mrad/h 5

Mulch 1-104

Multiple seating 12-3

Multiple-use 2-7

Multistage compressor 15-64

Naming DOE buildings, 10-2

National Institute of Standards and Technology; See NBS

National Pollutant Discharge Elimination System (NPDES) 5, 1-8, 1-41, 2-39, 2-44, 2-45

National Primary Drinking Water Standards (NPDWS) 5

National Security Agency (NSA) 6, 1-43, 1-79, 1-80, 1-83, 1-84, 16-2, 16-26

Nationally recognized testing laboratory (NRTL) 6, 21

Natural gas 1-40, 1-67, 2-15, 13-45, 13-52, 13-58, 15-55, 15-58

Natural phenomena 11, 1-35, 1-36, 1-97, 1-98, 2-2, 11-2, 13-3, 13-12, 13-68, 13-69, 13-90, 13-102, 13-110, 13-115, 13-120, 13-125, 15-20, 15-45

Near-real-time accountancy (NRTA) 6, 13-32

Nearby explosion 1-100

Net positive suction head (NPSH) 5

New Source Performance Standards (NSPS) 6, 15-73

New storage facility 21, 13-53, 13-59

Night vision device 2-63

Nitrogen (N_2) 5, 1-18, 1-27, 13-11, 13-31, 13-72, 13-118, 15-14, 15-15, 15-58, 15-69, 15-70, 15-72, 15-75

Noise 5, 30, 1-30, 1-77, 1-78, 1-106, 2-7, 2-8, 2-29, 2-56, 2-65, 2-69, 9-5, 13-34, 13-38, 13-42, 15-33, 15-37, 15-40, 15-41, 15-55, 15-69, 16-27

Noise criteria (NC) 5, 15-37, 15-41

Nonaqueous 15-12

Noncombustible 9, 1-79, 1-82, 9-3, 11-2, 11-3, 13-53, 13-59, 15-11, 15-39, 15-52, 15-69, 16-2, 16-15

Non-destructive assay (NDA) 5, 13-28-33, 13-45

Nonresidential 1-31

North American Datum (NAD) 5, 2-14

Nuclear 1, 6, 7, 10, 12, 16, 17, 20, 21, 22, 23, 24, 25, 26, 27, 28, 1-4, 1-8, 1-11, 1-12, 1-15-18, 1-22, 1-23, 1-26-29, 1-34, 1-35, 1-41, 1-42, 1-54, 1-58, 1-69, 1-71, 1-73, 1-74, 1- 76, 1-78, 1-92, 1-93, 1-97, 1-98, 2-3, 2-5, 2-45, 2-50, 2-51, 2-57, 2-61, 2-68, 3-2, 9-2, 13-1-3, 13-5-9, 13-11-13, 13-16, 13-18, 13-19, 13-21, 13-23, 13-25-32, 13-34, 13-44, 13-46, 13-48, 13-50-53, 13-56, 13-57, 13- 59, 13-61-63, 13-65, 13-66, 13-69, 13-70, 13-72, 13-73, 13-75-77, 13-80-82, 13-85, 13-86, 13-91-99, 13-104-107, 13- 111, 13-112, 13-116, 13-117, 13-121-123, 13-126, 13-127, 15-11, 15-12, 15-20, 15-21, 15-39, 15-42, 15-50, 15-76, 16-17

Nuclear accident dosimetry 13-11, 13-117, 13-123

Nuclear criticality safety 1-17, 1-18, 1-97, 2-51, 2-68, 13-5, 13-7, 13-8, 13-44, 13-50, 13-52, 13-56, 13-57, 13-59, 13-61-63, 13-70-72, 13-74, 13-75, 13-77, 13- 80-82, 13-85, 13-86, 13-91-99, 13-104, 13-106, 13-107, 13-111, 13-112, 13-117, 13-122, 15-21, 15-50, 15-76

Nuclear facility 12, 16, 21, 22, 1-4, 1-11, 1-16, 1-18, 1-22, 1-28, 1-35, 1-71, 1-73, 1-76, 1-93, 1-97, 2-3, 2-5, 2-45, 2-50, 2-68, 3-2, 9-2, 13-1-3, 13-6, 13-12, 13-13, 13-18, 13-19, 13-23, 13-25, 13-34, 13-44, 13-48, 13-51, 13-57, 13-62, 13-69, 13-76, 13-81, 13- 86, 13-92, 13-97, 13-105, 13-112, 13-116, 13-121, 15-11, 15-20, 15-42, 15-76, 16-17

Nuclear material 7, 10, 12, 17, 20, 22, 23, 24, 25, 26, 27, 1-11, 1-12, 1-69, 1-74, 2-57, 9-2, 13-3, 13-8, 13-9, 13-16, 13-21, 13-26-30, 13-32, 13-46, 13-66, 13-117, 13-121, 13-122, 13-126, 13-127

Nuisance 2-54, 2-55, 2-57, 2-65, 2-67, 13-42

Occupancy hazard classification 15-5

Occupational health facility 1-5, 1-77, 9-2, 13-2, 16-14

Occupiable 21, 1-59, 9-4, 10-2

Occupied area 21, 28, 2-50, 11-5, 13-9, 13-12, 13-65, 13-67, 15-19, 15-47, 15-69, 16-16

Off-gas 1-42, 2-1, 2-4, 13-13, 13-46, 13-48, 13-50, 13-74, 13-79, 13-80, 13-87, 13-89, 13-91, 13-95, 13-102, 13-107, 13-109, 13-112, 13-113, 13-119, 15-14, 15-15, 15-42, 15-44, 15-48-50

Office, see Secure Office

Office of Computer Services (OCS) 6, 1-81, 1-84, 2-9, 16-13, 16-27

Oil 6, 1-8, 1-19, 1-39, 1-40, 1-55, 2-31, 13-50, 13-81, 13-96, 13-115, 13-120, 13-126, 15-32, 15-35, 15-57, 15-64, 15-72, 15-73, 15-77, 16-8, 16-23

Oil-filled equipment 1-55, 16-8

Opacity 15-73

Open channel 14, 28, 2-42

Opening 27, 29, 1-70, 1-74, 1-80, 1-85-87, 2-17, 2-31, 2-38, 2-40, 2-59, 2-60, 7-5, 8-2, 8-3, 11-1, 15-30, 15-37, 15-67, 15-74, 16-3

Operable partition 10-4

Operating area compartment 11, 21, 13-13, 13-80, 13-96

Operating basis accident (OBA) 6, 21, 25

Operating basis earthquake (OBE) 6

Operating basis accident (OBA) 1-54

Operating cost 1-62, 15-25, 15-40

Operating efficiency 1-53, 1-74, 2-1, 2-30, 15-28

Operational compatibility 11-5

Operational phase 13-3

Operational Safety Requirement (OSR) 6, 22, 13-5, 13-114

Operations and maintenance (O&M) 6, 2-8, 11-3, 15-45, 15-62

Operator 9, 21, 22, 25, 26, 1-9, 1-48, 1-54, 1-64, 1-84, 1-93, 2-43, 2-44, 2-58, 8-7, 11-1, 11-3, 13-8, 13-14, 13-35-42, 13-48, 13-49, 13-58, 13-83, 13-87, 13-112, 15-13, 15-52, 15-67, 15-79, 15-81, 16-18, 16-19

Other facility 10, 1-6, 1-69, 1-72, 1-93, 2-5, 2-32, 2-43, 2-65, 13-4, 15-3, 15-34, 15-44

Other nuclear material 13-121, 13-126, 13-127

Outdoor air 15-28, 15-29, 15-37, 15-38, 15-79, 15-80, 15-82, 15-83

Outer vessel 15-66

Outside design temperature 15-26

Outside screw and yoke (OS&Y) 6, 15-11

Overall heat transfer coefficient value (U value) 8

Overhead 1-18, 1-26, 1-74, 1-78, 1-85, 1-105, 2-15-18, 2-31, 8-5, 8-6, 14-3, 16-6, 16-9

Overhead line 16-6

Overpressure 19, 22, 1-78, 13-64-67, 13-102

Oxidation 13-88, 13-120, 13-126

Oxides of nitrogen (NO_x) 5, 15-72, 15-73, 15-75

Oxygen deficiency hazards (ODH) 6, 15-70

Oxygen demand 2

Packaging 16, 1-11, 2-68, 13-34, 13-45, 13-52-54, 13-56, 13-58, 13-59, 13-61, 13-70, 13-108

Paint 1-18, 2-12, 2-59, 5-3, 9-1, 9-2, 16-23

Panel 1-23, 1-33, 1-72, 1-79, 1-86, 7-2, 7-3, 8-1, 8-5, 9-3, 13-11, 13-24, 13-37, 13-39, 13-40, 13-42, 13-43, 13-74, 15-14, 15-19, 15-60, 15-77, 16-16, 16-25, 16-26

Parking 16, 1-6, 1-103, 1-106, 1-108, 2-2, 2-4, 2-15, 2-19, 2-26, 2-27, 2-30, 2-39, 2-54, 2-56, 2-57, 7-13

Particulate 4, 17, 1-48, 1-105, 13-57, 13-62, 13-81, 13-87, 13-96, 13-116, 15-22, 15-28, 15-39, 15-45, 15-50, 15-75, 15-76

Partition 1-72, 1-73, 1-75, 1-91, 9-5, 10-3, 10-4, 12-2

Passive solar 1-61, 1-67

Patrol 1-70, 2-59, 2-60, 2-63, 13-25

Patrol road 2-59, 2-60

Patrol walkway 2-60

Pavement 9, 27, 1-30, 1-106, 2-10, 2-11, 2-16, 2-17, 2-24, 2-26-28, 2-30, 2-38, 2-54, 2-56, 2-58

Paving 2-19, 2-26, 2-28, 2-53, 2-54, 7-13

Peak positive incident pressure 22, 13-67

Pedestrian 1-69, 1-70, 1-103, 1-106, 2-5, 2-26, 2-42, 2-54, 2-55, 2-57, 2-58, 2-60-63, 2-69

Penetration 27, 28, 29, 1-23, 1-37, 1-49, 1-70, 1-72, 1-75, 1-84, 1-86-88, 1-98, 2-11, 2-17, 2-31, 2-39, 2-40, 2-53, 2-62, 7-3, 7-9, 7-10, 8-1-4, 13-9, 13-21, 13-23, 13-26, 13-27, 13-49, 13-55, 13-61, 13-73, 13-74, 13-80, 13-84, 13-90, 13-96, 13-110, 13-120, 13-125, 14-1, 15-16, 15-19, 15-40, 15-41, 15-53, 16-3, 16-6, 16-7

Penetration delay 1-70, 1-87, 2-17, 2-31, 2-39, 2-40, 2-53, 15-16, 15-41

Permafrost 22, 2-64

Permanent equipment 16-20, 16-23

Permissible exposure limit (PEL) 6, 15-29

Permit 1-9, 1-105, 2-39, 13-15, 15-74, 15-75

Personnel monitoring 13-10

Personnel safety 1-58, 16-14

Personnel ventilation air requirement 15-29

Pervious 22, 2-38

Petroleum, oil, and lubricants (POL) 6, 2-31

pH 22, 2-50

Photoelectric 15-72, 15-73

Photographic 2-7

Photovoltaic 1-61

Physical barrier 21, 23, 25, 28, 1-49, 1-70, 1-72, 2-61, 8-4, 11-1, 13-8, 13-21, 13-27, 13-29, 15-42

Physical protection 22, 24, 26, 1-11, 1-68, 1-74, 1-80, 1-87, 2-2, 2-4, 2-7, 2-8, 2-19, 2-54, 2-56, 2-57, 2-60, 2-62, 11-5, 13-9, 13-16-19, 13-21, 13-26, 13-27, 13-69, 13-121, 13-127, 16-7, 16-19

Physical security 22, 1-27, 1-79, 1-80, 1-82, 1-85, 2-53, 8-2, 8-3, 8-7, 13-27, 13-28

Physically handicapped 1-6, 1-7, 1-57, 1-76, 1-77, 2-26, 2-54, 2-55, 10-5, 13-44, 14-2, 14-3, 15-16

Physically separated 22, 1-74, 13-53, 13-59, 16-24

Pier 10, 1-15, 1-89, 2-22

Pipe 2, 7, 16, 1-17, 1-22, 1-75, 1-88, 2-12, 2-14, 2-23, 2-32, 2-35, 2-38, 2-39, 2-42, 2-49-51, 2-64, 2-65, 7-9, 7-10, 13-13,

Double-hypen entries indicate inclusive pages, e.g., "3-27-29" means page 3-27 through page 3-29.
Entries for singular words can include plurals.

13-14, 13-32, 13-45, 13-46, 13-49, 13-56, 13-102, 15-1, 15-5, 15-6, 15-10, 15-14, 15-15, 15-17, 15-22, 15-23, 15-31, 15-35-37, 15-51, 15-53, 15-58, 15-60, 15-61, 15-66-68, 15-81, 16-23

Pipe joint 2-35, 2-38, 2-39, 2-49

Piped utility material 2-31, 2-32, 2-34, 15-10

Piping 1-22, 1-25, 1-27, 1-72, 1-74, 1-82, 1-90, 1-108, 2-18, 2-31, 2-32, 2-48, 2-49, 7-3, 7-5, 7-10, 11-3, 13-7, 13-14, 13-16, 13-27, 13-32-34, 13-46, 13-47, 13-51, 13-73, 13-77, 13-79, 13-83, 13-92, 13-94, 13-95, 13-98-100, 13-102, 13- 103, 13-113, 13-118, 13-119, 15-1, 15-4, 15-6, 15-16, 15-17, 15-19, 15-20, 15-22, 15-23, 15-35-37, 15-43, 15-54, 15-57, 15-60, 15-61, 15-66-70, 15-75, 15-77, 15-81, 15-82

Plaster 1-33, 9-3-5

Plastic 22, 1-21, 1-33, 1-55, 1-96, 2-20, 2-48, 2-62, 4-2, 6-1, 7-5, 8-3-6, 10-1, 10-3, 10-4, 13-26, 13-69, 13-80, 13-96, 13-115, 13-118, 15-17, 15-33, 15-77, 16-7

Plastic design 1-21

Plastic structure 6-1

Plastic yielding 22, 2-20

Plastomeric sheet roofing 7-11

Plumbing 5, 6, 8, 1-32, 1-33, 1-36, 1-37, 1-90, 13-14, 13-16, 15-16, 15-19

Plutonium (Pu) 4, 6, 22, 27, 1-4, 1-5, 1-18, 1-42, 1-97, 9-2, 9-7, 13-2, 13-44-55, 13-57, 13-62, 13-63, 13-65, 13-66, 13-68, 13-69, 13-86, 13-115, 15-13, 15-46, 15-47, 15-52

Plutonium processing and handling facility (PPHF) 6, 22, 1-4, 13-2, 13-4, 13-44-46, 13-49-51

Plutonuum storage facility (PSF) 5, 6, 22, 1-5, 1-91, 1-97, 13-2, 13-4, 13-51-54, 13-56

Point of intersection (PI) 6, 14, 2-16

Point of nearest public access 22

Pole 1-21, 1-86, 1-105, 2-15, 2-17, 5-2, 8-7, 15-60, 16-6, 16-12, 16-21, 16-24, 16-27

Pollutant 2, 5, 1-8, 2-33, 2-37, 2-44, 2-46, 15-10, 15-71

Pollution 4, 8, 1-8, 1-9, 1-12, 1-31, 1-49, 1-57, 1-105, 1-106, 2-31, 2-43, 2-46, 2-47, 2-56, 13-14, 13-16, 15-55, 15-71, 15-72, 15-75

Polybutylene (PB) 6, 1-29, 7-8, 15-17

Polychlorinated biphenyls (PCB) 6, 1-9, 1-55, 2-18, 16-8

Polyvinyl chloride (PVC) 2, 6, 2-39, 15-17

Portable building 13-63

Portland cement 22, 1-44, 2-60, 3-4, 9-3

Positive access control 13-23, 13-67

Post indicator valve (PIV) 6, 15-11

Post-tensioned 1-45, 3-3

Postal 8, 10-3

Potable water 12, 14, 1-108, 2-15, 2-33, 2-38, 2-46, 15-10, 15-16, 15-18, 15-19, 15-23

Potential accident 1-54, 2-1, 13-3

Pounds per linear foot (PLF) 6, 1-91

Power 3, 8, 14, 27, 29, 1-9, 1-17, 1-18, 1-22, 1-23, 1-29, 1-31, 1-32, 1-34, 1-35, 1-40-42, 1-60, 1-72, 1-79, 1-82, 1-85-87, 1-104, 2-15, 2-19, 2-52, 2-60-63, 5-2, 11-4, 13-10, 13-23-26, 13-28, 13-71, 13-73, 13-74, 13-122, 14-1, 14-2, 15-3, 15-12, 15-14, 15-20, 15-44, 15-46, 15-47, 15-49, 15-51, 15-53, 15-58, 15-65, 15-82, 16-1-3, 16-5-9, 16-11-20, 16-24, 16-25

Power factor 1-60, 16-5, 16-11

Power generation 14, 27, 2-52, 16-5

Power outage 2-60, 2-61, 15-12, 15-53, 15-65

Power panel 1-72

Power quality 16-5, 16-11

Power service 14-1, 14-2, 16-9, 16-12, 16-13

Power source 1-79, 1-87, 2-19, 2-63, 13-24, 15-12, 15-44, 15-51, 16-8, 16-13, 16-14, 16-16, 16-17, 16-20, 16-24, 16-25

Power supply 8, 14, 29, 1-79, 2-52, 2-61, 13-10, 13-23, 13-25, 15-47, 16-6, 16-8, 16-9, 16-11, 16-13, 16-14, 16-17, 16-24, 16-25

Power system 3, 14, 27, 1-18, 1-34, 1-40, 2-61, 13-26, 13-71, 13-122, 16-11, 16-16-18

Preaction 15-6

Precast concrete 3-3, 3-4

Precipitation 21, 23, 1-41, 2-40, 2-41, 13-53, 13-59, 13-86, 13-94, 13-98, 13-100, 13-101

Pre-engineered 10, 1-1, 1-59, 1-61, 1-87, 1-110, 5-1

Prefabricated 1-96, 2-27, 3-4

Pre-filter 15-39

Preliminary Safety Analysis Report (PSAR) 6, 22, 1-54

Preparation area 13-72

Preservation 5, 1-9, 1-82, 1-104, 2-69

Double-hyphen entries indicate inclusive pages, e.g., “3-27-29” means page 3-27 through page 3-29.
Entries for singular words can include plurals.

Pressure 9, 10, 12, 13, 15, 16, 19, 21, 22, 25, 30, 1-20, 1-22, 1-25, 1-91-94, 1-96, 1-98, 2-10, 2-23, 2-34, 2-35, 2-50, 2-62, 7-1, 7-4, 11-2-4, 13-5-7, 13-31, 13-42, 13-48, 13-55, 13-61, 13-67, 13-69, 13-72, 13-74, 13-75, 13-78, 13-80, 13-85, 13-87, 13-90, 13-93, 13-96, 13-110, 13-113, 13-115, 13-118-120, 13-123-126, 15-3-6, 15-10, 15-15, 15-18-20, 15-29, 15-30, 15-32-37, 15-39, 15-41-44, 15-47, 15-48, 15-52, 15-53, 15-55-58, 15-60, 15-61, 15-64-68, 15-70, 15-77, 15-79-82, 16-15, 16-19

Pressure modification 15-18

Pressure-reducing valve 15-18

Pressure relief device 1-25, 15-66, 15-68

Pressure switch 15-32

Pressure vessel pumping 15-65

Pressurization 1-100, 1-108

Pressurization 11-4, 13-88, 15-13, 15-29, 15-40, 15-48, 15-58, 15-70, 15-80

Prestressed concrete 6, 1-44, 3-1, 3-4

Primary confinement 11, 15, 22, 1-73, 13-13, 13-46-48, 13-54, 13-60, 13-74, 13-75, 13-77-80, 13-84, 13-87-90, 13-93, 13-95, 13-96, 13-98, 13-101-103, 13-106, 13-107, 13-109, 13-113-115, 13-118-120, 13-124, 15-24

Primary power 14, 2-52, 13-24, 16-8, 16-13, 16-16, 16-17, 16-25

Private industry 1-26, 1-32

Probable maximum flood (PMFL) 6, 23, 1-99, 2-6

Process enclosure 11, 21, 13-13, 13-77, 13-78, 13-92, 13-98, 15-47

Process energy 1-62-64, 1-66-68, 15-83

Process wastes 2-50, 13-62, 13-75, 13-85, 13-91, 13-104, 13-111, 13-114, 13-115

Processing 1, 4, 6, 8, 10, 11, 15, 16, 22, 24, 26, 1-4, 1-5, 1-8, 1-9, 1-27, 1-32, 1-39, 1-42, 1-71, 1-73, 1-79-81, 1-83, 1-93, 2-1, 2-7, 2-51, 7-6, 9-4, 13-2, 13-28, 13-29, 13-31, 13-32, 13-44, 13-46-48, 13-61, 13-62, 13-66, 13-68, 13-71, 13-73, 13-75-78, 13-80, 13-81, 13-85, 13-88, 13-91-94, 13-96, 13-97, 13-104, 13-109, 13-111, 13-114, 13-116, 13-117, 13-122, 13-124, 15-12, 15-14, 15-47, 15-52, 16-9, 16-11, 16-20, 16-26

Processing facility 7-6, 13-31, 13-61, 13-62, 13-75, 13-80, 13-81, 13-85, 13-91, 13-96, 13-104, 13-111, 13-116

Procurement 1-8, 5-1, 15-2

Production method 2-47

Programmatic 1-2, 1-51, 1-52, 1-58, 2-1, 13-18, 13-52, 13-58

Programming 1-51, 1-65, 15-62

Project design criteria 23, 1-53, 15-31

Property line 26, 1-108

Property protection area 23, 1-68, 1-69

Proportional-plus integral (PI) 6

Proposal 1-6, 2-52

Protected area (PA) 6, 21, 23, 1-22, 1-25, 1-26, 1-32, 1-37, 1-68-70, 1-79, 2-18, 2-23, 2-27, 2-61, 9-5, 10-2, 13-18, 13-20-23, 13-25, 13-27, 13-29, 15-6, 16-25, 16-26

Protection 3, 4, 5, 6, 9, 10, 12, 13, 15, 17, 18, 19, 20, 22, 23, 24, 25, 26, 27, 28, 29, 1-2, 1-3, 1-7-12, 1-17, 1-19, 1-25, 1-27-29, 1-31, 1-34, 1-38-40, 1-42, 1-53, 1-55-57, 1-68-76, 1-79, 1-80, 1-82, 1-83, 1-85, 1-87, 1-89, 1-93, 1-105, 1-106, 1-109, 2-1-4, 2-7, 2-8, 2-11, 2-19, 2-31-34, 2-39, 2-43, 2-44, 2-46, 2-48, 2-49, 2-51, 2-52, 2-54-64, 2-66, 7-1, 7-8, 7-13, 8-1, 8-3, 8-8, 9-1, 10-3, 11-2, 11-4, 11-5, 13-3, 13-4, 13-8, 13-9, 13-11, 13-15-21, 13-24-27, 13-38, 13-39, 13-45, 13-47, 13-50, 13-51, 13-54, 13-56, 13-58, 13-60, 13-64-69, 13-77, 13-78, 13-83, 13-88, 13-93, 13-98, 13-99, 13-101, 13-103, 13-106, 13-107, 13-113-115, 13-117, 13-121, 13-123, 13-127, 15-2-7, 15-9-16, 15-19, 15-40, 15-46, 15-49, 15-50, 15-61, 15-65, 15-71, 15-76, 15-77, 15-80, 16-3, 16-7-9, 16-11, 16-12, 16-16, 16-18-23, 16-26

Protection factor (PF) 6, 1-58

Protective 10, 1-11, 1-16, 1-18, 1-27, 1-35, 1-39, 1-41, 1-44, 1-69, 1-78, 1-79, 1-86, 2-7, 2-31, 2-32, 2-54, 2-55, 2-59, 2-62, 2-63, 7-1, 7-2, 7-4, 8-8, 9-7, 10-3, 13-11, 13-17, 13-23-25, 13-38-40, 13-52, 13-58, 13-64, 13-65, 13-73, 13-108, 13-118, 13-123, 14-2, 15-24, 15-45, 15-49, 16-6, 16-7, 16-13, 16-15, 16-16, 16-18-20, 16-24

Public address 1-52, 16-26

Public funds 1-51

Public highway 22, 2-23, 2-57

Public review 2-51, 2-52

Public road 15-69

Public safety 1-76, 1-93

Public Traffic Route Distance 16-21, 16-22

Publicly-owned treatment works (POTW) 6, 2-43

Pump 1-38, 1-64, 1-67, 2-23, 13-7, 13-39, 13-87, 15-10, 15-18, 15-21, 15-31, 15-34-36, 15-43, 15-52, 15-58-60, 15-65, 15-67, 15-81

Pumping system 15-35, 15-36, 15-81

Purchase 10, 1-2, 16-24

Pyrophoric 23, 13-48, 13-54, 13-60, 13-113, 13-114, 15-6, 15-12

Double-hyphen entries indicate inclusive pages, e.g., "3-27-29" means page 3-27 through page 3-29. Entries for singular words can include plurals.

Quality assurance (QA) 7, 23, 1-12, 1-22, 1-101, 1-102, 1-108, 13-5, 13-47, 15-70, 16-17

Quality control 23, 1-44, 1-101, 1-102, 3-2, 3-3

Quantity-distance (separation) 19, 20, 23, 13-63, 13-64, 16-22

Quick-response 15-7

Raceway 16-2, 16-3, 16-10, 16-27

Radiant flux 1-23, 9-6, 12-2, 12-3

Radiation 5, 9, 12, 22, 1-7, 1-8, 1-10, 1-11, 1-17, 1-28, 1-29, 1-42, 1-53, 1-54 1-58, 1-73, 1-74, 1-76, 1-83, 2-2, 2-3, 2-33, 2-50, 2-68, 9-3, 11-2, 11-3, 13-3, 13-4, 13-8-11, 13-15, 13-16, 13-23, 13-28, 13-31, 13-34, 13-38, 13-39, 13-45, 13-50, 13-54, 13-56, 13-58, 13-68, 13-69, 13-73, 13- 82, 13-83, 13-99, 13-103, 13-105-107, 13-113, 13-117, 13-121-123, 15-9, 15-35, 15-43, 15-45, 15-49, 15-50, 15-56, 15-76, 16-27

Radiation exposure 12, 1-42, 13-4, 13-8-10, 13-45, 13-54, 13-113, 13-117, 13-123

Radiation monitoring 1-73, 13-9-11, 13-69, 13-117, 13-123

Radiation protection 9, 22, 1-8, 1-10, 1-11, 1-29, 1-73, 1-76, 2-33, 13-4, 13-9, 13-11, 13-15, 13-16, 13-45, 13-50, 13-56, 13-58, 13-68, 13-82, 13-83, 13-99, 13-106, 13-107, 13- 113, 13-117, 13-123, 15-49, 15-50, 15-76

Radiation shielding 1-17, 1-58, 9-3, 11-2, 13-9, 13-34, 15-45

Radio 23, 1-5, 1-43, 1-78, 1-84, 1-86, 2-7-9, 13-2, 13-23, 13-25, 15-13, 15-14, 15-52, 15-53, 16-9, 16-14, 16-15, 16-26

Radio antenna 1-84

Radio control center 1-84, 2-8, 13-23, 15-52, 16-14

Radio repeater station 23, 1-5, 1-78, 1-86, 2-7, 2-9, 13-2, 15-13, 15-14, 15-52, 15-53, 16-9, 16-14, 16-15

Radioactive 7, 9, 11, 12, 17, 20, 21, 28, 30, 1-5, 1-7, 1-8, 1-11, 1-12, 1-18, 1-56, 1-57, 1-71, 1-73, 1-77, 1-93, 1-97, 1-98, 2-2, 2-3, 2-5, 2-6, 2-18, 2-44-46, 2-50, 2-51, 2-63-68, 9-1, 9-2, 11-1-3, 12-1, 12-3, 13-2, 13-3, 13-5, 13-10, 13-12-17, 13-33, 13-34, 13-45, 13-49, 13-50, 13-52, 13-55-58, 13-60-62, 13-69, 13-75, 13- 80-85, 13-91, 13-94, 13-96-107, 13-109-111, 13-115, 13-116, 13-120-122, 13-126, 15-20-22, 15-24, 15-25, 15-42, 15-45-50, 15-76, 16-9

Radioactive airborne effluent 13-50, 13-57, 13-62, 13-75, 13-81, 13-85, 13-91, 13-97, 13-104, 13-111, 13-116, 13-121, 15-76

Radioactive liquid waste 1-5, 2-50, 7, 13-2, 13-50, 13-56, 13-62, 13-75, 13-81, 13-85, 13-91, 13-96-101, 13-103, 13-104, 13-111, 13-115, 13-126,

Radioactive liquid waste facility (RLWF) 13-2, 13-97-101, 13-104, 1-5, 7

Radioactive material 9, 11, 21, 30, 1-18, 1-71, 1-73, 1-93, 1-97, 2-2, 2-3, 2-5, 2-68, 9-2, 11-2, 11-3, 12-1, 12-3, 13-3, 13-5, 13-10, 13-14, 13-17, 13-45, 13-52, 13-55, 13-56, 13-58, 13-60, 13-69, 13-80, 13-83, 13-84, 13-94, 13- 96, 13-99, 13-100, 13-102, 13-105, 13-111, 13-122, 15-21, 15-22, 15-45, 15-47-50

Radioactive solid waste 7, 1-5, 2-63, 2-64, 2-67, 2-68, 13-2, 13-49, 13-56, 13-61, 13-75, 13-80, 13-85, 13-91, 13-96, 13-105-107, 13-109-111, 13-115, 13-126, 15-24, 15-25

Radioactive solid waste facility (RSWF) 7, 1-5, 2-68, 13-2, 13-105-107, 13-109, 13-111, 15-24, 15-25

Radioactive waste 17, 20, 28, 1-7, 1-8, 1-12, 2-44, 2-46, 2-51, 2-63, 2-65, 2-66, 13-14, 13-50, 13-61, 13-62, 13-75, 13-80-82, 13-85, 13-91, 13-96, 13-104, 13-111, 13-115, 13-116, 13-120, 15-46

Radioactivity monitor 2-50, 13-51, 13-78

Radioiodine 13-84, 13-85, 13-87, 13-112-115, 15-48

Radiological design requirement 9-2

Radiological siting 2-2-4

Radionuclide 28, 1-8, 2-33, 13-4, 13-11, 13-15, 13-44, 13-51, 13-87, 13-103, 13-107, 13-117, 15-49, 15-50, 15-52, 15-76

Rail 11, 1-43, 1-68, 2-23-26, 2-53, 2-58, 2-59, 16-15

Rail anchor 2-25

Railroad 9, 23, 2-23-27, 2-35

Railway 1, 1-19, 1-90-92, 1-94-97, 2-5, 2-23-26, 2-53, 3-1, 3-2, 3-5, 4-1, 5-2, 5-3, 6-1

Raised floor 1-82

Rational method 23, 2-41

Real Property and Facilities Management (RPFM) 7, 1-6, 1-7

Real Property Inventory System (RPIS) 7, 24, 1-7

Receiver 1-84, 15-34, 15-73, 16-14

Receiving stream 24, 2-43

Receptacle 1-76, 15-39, 15-51, 16-5, 16-11, 16-14

Reciprocating compressor 15-32, 15-64

Recirculating air 15-38, 15-42

Recirculation 1-71, 13-31, 13-78, 15-1, 15-10, 15-29, 15-33, 15-46, 15-47, 15-72

Reclamation 2-64, 13-111

Double-hyphen entries indicate inclusive pages, e.g., "3-27-29" means page 3-27 through page 3-29. Entries for singular words can include plurals.

Record 23, 1-7, 1-12, 1-40, 1-81, 1-82, 1-101, 1-107, 1-108, 2-16, 2-18, 2-33, 2-40, 2-41, 2-66, 13-11

Record drawing 1-107, 2-16, 2-18, 2-33

Recycle 2-47, 13-75, 15-62

Redundancy 11-4, 13-6, 13-12, 15-4, 15-20, 15-21, 15-27, 15-34, 15-35, 15-40, 15-49, 16-6, 16-18-20

Redundant 14, 27, 13-6, 13-22, 13-25, 13-48, 13-80, 13-90, 13-96, 15-3-5, 15-11, 15-13, 15-46, 15-47, 15-54, 15-67, 15-76, 16-6, 16-18, 16-19, 16-26

Reflector 13-94, 16-27

Refractory 24, 1-22, 4-2, 4-3

Refuse 7, 1-104, 1-105, 2-4, 2-57, 2-65, 15-74

Refuse-derived fuel (RDF) 7

Regional frequency analysis 24

Regional system 2-64

Regulation 1-4, 23, 1-1-5, 1-7-9, 1-31, 1-43, 1-105, 2-18, 2-23, 2-39, 2-43, 2-46, 2-48, 2-52, 2-63, 2-66, 10-2, 13-3, 13-15, 13-105, 15-35, 15-56, 15-59, 15-62, 15-71, 15-74, 15-75, 15-77

Regulatory 6, 7, 1-4, 1-7, 1-10, 1-24-27, 1-30, 1-32, 1-38, 1-40, 1-41, 1-44-46, 1-48, 1-49, 1-57, 2-23, 2-33, 2-43, 2-44, 2-46, 2-51, 2-63, 13-5, 13-88, 15-56

Reinforced concrete 7, 17, 24, 27, 1-15, 3-4

Reinforced concrete pipe (RCP) 7

Reinforcement 24, 3-2, 4-2, 7-2, 7-5, 7-7-9

Reinforcement ratio 24

Relative humidity 15-25, 15-26, 15-78

Relayer rail 2-24, 2-25

Remote interrogation point 24, 1-79, 1-80, 16-26

Renewable energy 1-59, 1-61, 1-66, 1-67, 15-78, 15-83

Renewable system 1-61

Renovation 1-75, 2-8, 7-7

Repair 18, 1-15, 1-55-58, 1-75, 2-49, 2-55, 2-65, 2-68, 3-4, 3-5, 7-2, 7-10, 8-3, 13-6, 13-13, 13-45, 13-72, 13-114, 13-117, 15-46, 15-62, 15-63, 15-74

Repeater station 23, 1-5, 1-78, 1-86, 2-7, 2-9, 13-2, 15-13, 15-14, 15-52, 15-53, 16-9, 16-14, 16-15

Replacement 11, 1-56-58, 1-75, 1-78, 8-3, 11-2, 11-3, 13-6, 13-7, 13-74, 13-78, 13-93, 15-19, 15-47, 15-48, 15-50, 15-62, 15-63, 16-24

Reprocessing 17, 1-5, 1-42, 13-2, 13-76, 13-82, 13-86-89, 13-91, 13-97, 13-105, 15-24

Required strength 24

Requirements analyses 13-35

Rescue 1-30, 1-40, 2-30, 14-2

Reservoir 24, 25, 1-24, 2-11, 2-38, 2-42, 5-2

Reservoir routing 24

Residence 2-67

Resilient flooring 9-2, 9-3, 9-6

Resinous flooring 9-6

Resonance 1-94, 1-96

Response time 24, 2-61, 13-42, 15-6

Rest room 15-29

Restoration 1-9, 2-19, 2-69, 3-4, 3-5, 13-42

Retaining wall 24, 1-94, 2-56

Return air 15-37, 15-79

Return period 24, 1-41

Revegetation 1-104, 2-69, 13-108,
Reweldable joint 15-67

Right-of-way 26, 2-12, 2-16, 2-43

Riser 2-35, 15-4, 15-5, 15-10, 15-11, 15-17, 15-68

Road 16, 21, 23, 1-14, 1-20, 1-23-26, 1-33, 1-35, 1-37, 1-43-48, 1-103, 1-106, 1-108, 2-2, 2-4, 2-15, 2-17, 2-19, 2-26, 2-27, 2-29, 2-56, 2-59, 2-60, 2-65, 2-67, 7-13, 13-67, 15-69

Roadway 9, 11, 28, 1-18, 1-105, 1-106, 2-15-17, 2-27, 2-35, 2-38, 2-42, 2-43, 2-54, 2-57, 2-60, 15-60

Roentgen equivalent man (REM) 5, 7, 14, 24, 2-2, 2-3, 13-9

Roof 1-44, 1-45, 1-56, 1-63, 1-70, 1-74, 1-78, 1-81, 1-84-87, 1-89, 1-91, 1-97, 2-42, 3-4, 5-3, 7-3, 7-5, 7-6, 7-8-13, 9-1, 9-5, 13-13, 13-47, 15-22, 15-33, 16-3

Roof-mounted equipment 7-10

Roofing 1, 6, 7, 1-20, 1-42, 1-43, 1-47, 7-3, 7-6, 7-8-13

Roofing tile 7-9

Room envelope 1-88, 1-89, 15-53

Rotary heat exchanger 15-31

Routine release 13-4, 13-15, 13-57, 13-62, 13-87, 13-102, 13-105, 13-106, 13-112, 15-48, 15-76

Double-hyphen entries indicate inclusive pages, e.g., “3-27-29” means page 3-27 through page 3-29. Entries for singular words can include plurals.

Rug 2, 1-8, 1-26, 12-2, 12-3

Runoff 21, 23, 2-6, 2-40-44, 2-69, 13-108, 15-21, 15-22, 15-58

Rupture disk 13-119, 15-32

Sabotage 24, 1-68, 1-70, 13-16-19, 13-21, 13-25, 13-26

Safe shutdown earthquake (SSE) 7, 13, 24, 1-99

Safe surface temperature 15-1

Safeguard 3, 5, 6, 7, 12, 13, 23, 24, 26, 27, 1-11, 1-27, 1-28, 1-80, 1-103, 2-2, 2-4, 2-7, 2-34, 2-39, 2-44, 2-54-58, 2-61, 8-2, 8-7, 11-5, 13-3, 13-8, 13-9, 13-16, 13-17, 13-21, 13-26, 13-27, 13-29, 13-69, 13-78, 13-121, 13-127, 15-58, 16-16

Safeguards and security (S&S) 3, 5, 6, 7, 12, 13, 27, 1-11, 1-28, 1-103, 2-56, 2-57, 8-2, 8-7, 11-5, 13-3, 13-16, 13-17, 13-26, 13-69, 16-16

Safety 2, 3, 4, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 21, 22, 23, 25, 26, 28, 29, 1-1-3, 1-8, 1-11, 1-15-18, 1-20, 1-21, 1-26, 1-27, 1-30, 1-33-35, 1-40, 1-47-49, 1-53, 1-54, 1-56, 1-58, 1-60, 1- 65, 1-66, 1-68, 1-71-76, 1-90, 1-92, 1-93, 1-97-101, 1-110, 2-1, 2-3-5, 2-20, 2-27, 2-28, 2-30, 2-33, 2-42, 2-43, 2-50, 2-51, 2-53, 2-68, 8-1, 8-3, 11-3, 11-4, 13-1, 13-3-8, 13-10, 13-12, 13-17, 13-18, 13-30, 13-31, 13-35, 13-36, 13-40, 13-44, 13-46, 13-49-53, 13-55-57, 13-59, 13-61-66, 13- 68, 13-70-72, 13-74, 13-75, 13-77, 13-80-87, 13-90-99, 13-104-107, 13-111, 13-112, 13-115-118, 13-120, 13- 122, 13-124, 13-125, 15-2, 15-11-13, 15-16, 15-18, 15-20-22, 15-24, 15-25, 15-29, 15-30, 15-32, 15-35, 15-39, 15-42, 15-44-47, 15-49, 15-50, 15-60, 15- 65, 15-70, 15-76, 15-77, 15-80, 16-6-8, 16-10, 16-12, 16-14-20

Safety analysis 4, 6, 7, 9, 22, 25, 1-2, 1-11, 1-30, 1-54, 1-74, 1-98, 1-100, 2-50, 11-3, 13-1, 13-4, 13-5, 13-8, 13-12, 13-53, 13-55, 13-59, 13-61, 13-68, 13-84, 13-115-118, 13-120, 13-124, 13-125, 15-11, 15-21, 15-39, 15-45-47, 15-50

Safety analysis and review system (SARS) 7, 1-11

Safety analysis report (SAR) 4, 6, 7, 22, 25, 1-2, 1-54, 1-56, 1-99, 2-3

Safety class (SC) 7, 11, 12,, 13, 14, 15, 25, 26, 27, 1-3, 1-46, 1-75, 1-97-101, 2-5, 11-4, 13-5-8, 13-46, 13-53, 13-55, 13-59, 13-61, 13-66, 13-71, 13-82-84, 13-87, 13-107, 15-11, 15-13, 15-20, 15-24, 15-25, 15-42, 15-44-47, 15-49, 16-16-20

Safety class item 11, 12, 13, 25, 2-5, 11-4, 13-5-7, 13-46, 13-53, 13-59, 13-82, 13-84, 13-87, 15-20, 15-42, 15-45, 16-18

Safety devices 29, 15-16, 15-18

Safety factor (SF) 7

Safety hazards 1-56, 1-97, 13-36

Safety limit 15, 16, 25, 13-5, 13-77

Safety margins 1-54

Safety personnel 16-10

Sampling 1-18, 1-23, 1-76, 2-9, 2-10, 2-50, 13-10, 13-13, 13-15, 13-28, 13-30, 13-31, 13-50, 13-56, 13-70, 13-72, 13-83, 15-21, 15-45, 15-59, 15-73, 15-76

Sampling area 13-72

Sand coating 2-60

Sanitary engineering 25, 1-15, 3-1

Sanitary landfill 25, 2-47

Sanitary sewer 2-17

Sanitary waste 2-45, 2-46, 15-23

Sanitary wastewater 1-104, 1-106, 2-17, 2-19, 2-37, 2-43-46

Satellite facility 15-55

Saturated zone 25, 2-45, 2-66

Schedule 11, 1-2, 1-63, 1-64, 1-73, 1-107, 1-110, 2-33, 2-37, 11-1, 13-7, 13-25, 13-34, 15-5, 15-6, 15-17, 15-36, 15-37, 15-61, 15-67

Scrap 1-73, 13-30, 13-46, 13-80, 13-81, 13-92-94, 13-96

Screen 7, 1-46, 8-2-4, 8-6, 10-1, 11-4, 15-40

Screw compressor 15-64

Scrubber 13-80, 13-91, 13-95, 13-113-115, 15-14, 15-15, 15-48, 15-49

Seal pot 13-119

Sealant 1-14, 1-31, 7-13, 8-8

Seasonal 1-94, 2-10, 2-66, 8-3, 15-56

Secondary alarm station (SAS) 7, 13-23, 13-25

Secondary confinement 11, 29, 1-73, 13-13, 13-14, 13-47, 13-48, 13-54, 13-55, 13-60, 13-61, 13-74, 13-75, 13-79, 13-80, 13-84, 13-88-90, 13- 95, 13-96, 13-100-104, 13-109, 13-110, 13-113-115, 13-119, 13-120, 13-123-126

Sectional overhead door 8-6

Secure 14, 25, 26, 1-5, 1-74, 1-78-80, 1-82, 1-87-89, 2-18, 2-31, 9-4, 9-5, 9-6, 13-2, 13-24, 13-53, 13-59, 14-1, 14-2, 15-53, 15-54, 16-2, 16-5, 16-25-27

Secure communications 25, 26, 1-80, 16-26, 16-27

Secure conference room 1-5, 1-88, 9-5, 13-2, 15-53, 15-54, 16-26

Secure office 1-5, 1-79, 1-88, 1-89, 9-6, 13-2, 16-26

Secured area 15, 2-7, 2-8, 2-57, 2-58

Security 2, 3, 5, 6, 7, 10, 11, 12, 13, 14, 15, 17, 20, 22, 23, 25, 26, 27, 28, 29, 1-10-12, 1-27, 1-28, 1-32, 1-43, 1-52, 1-56, 1-68, 1-69, 1-73, 1-79, 1-80, 1-82, 1-83, 1-85, 1-87-89, 1-103, 1- 104, 1-106, 1-107, 1-109, 2-2, 2-4, 2-5, 2-8, 2-17-19, 2-23, 2-27, 2-31, 2-34, 2-37-40, 2-44, 2-52-62, 2-69, 8-1-3, 8-5, 8-7, 8-8, 9-4-6, 10-2, 11-5, 13-3, 13-8, 13-16-28, 13-69, 14-1, 14-2, 15-16, 15-41, 15-52-54, 15-75, 15-77, 16-3, 16-6-8, 16-12-14, 16-16, 16-21, 16-24, 16-26-28

Security agreement 3, 5, 1-11

Security alarm 1-85, 1-87, 2-8, 2-53, 13-23, 15-52, 15-53, 16-16, 16-21, 16-24

Security alarm control center 1-85, 2-8, 13-23, 15-52, 15-53

Security area 11, 15, 20, 25, 26, 29, 1-68, 1-69, 1-73, 1-79, 1-80, 1-83, 1-85, 1-87, 2-17, 2-18, 2-23, 2-27, 2-31, 2-57-60, 8-2, 8-7, 9-5, 9-6, 13-18-21, 13-24, 13-25, 16-26

Security fence/fencing 1-104, 1-106, 1-107, 2-17, 2-31, 2-40, 2-53, 2-57-60, 13-21

Security force 1-79, 1-83, 2-60, 13-25

Security inspector post 2-61, 2-62, 13-25

Security interest 26, 27, 1-68, 2-57, 13-17, 13-19, 13-21

Security Office 2-8, 16-28

Security Officer 2, 2-59, 2-60, 15-75

Security protection 28, 1-80

Sediment 2-42

Sedimentation 2-67

Seismic 14, 26, 1-14, 1-20, 1-35, 1-36, 1-42, 1-93, 1-96, 1-99, 1-100, 2-2, 2-9, 2-11, 2-49, 2-55, 2-64, 11-2, 13-6, 13-68, 15-17, 15-22, 15-44, 16-7, 16-17, 16-18

Self-restoring 15-6

Separation and physical protection 16-19

Service 4, 6, 7, 8, 18, 20, 23, 26, 1-10, 1-13, 1-20, 1-33, 1-39-41, 1-43, 1-45, 1-52, 1-53, 1-71, 1-72, 1-76, 1-79, 1-81, 1-83, 1-84, 1-90, 1-96, 1- 101, 1-104, 1-105, 1-109, 2-2, 2-4, 2-5, 2-7-9, 2-17, 2-18, 2-20, 2-32, 2-34, 2-35, 2-38, 2-41, 2-44, 2-52, 2-55, 2-65, 2-68, 2-69, 7-12, 7-13, 9-2, 9-3, 9-5, 11-2, 13-14, 13-16, 13-25, 13-33, 13-42, 13-43, 13-69, 13-70, 13-99, 13-103, 13-117, 14-1-3, 15-1, 15-16-18, 15-21, 15-22, 15-36, 15-39, 15-41, 15-48, 15-53, 15-57-59, 15-61, 15-64, 15-67, 16-2, 16-5-9, 16-11-14, 16-16, 16-21, 16-22, 16-24, 16-25, 16-27, 16-28

Service entrance 16-22

Service equipment 1-90, 2-69, 16-9, 16-11

Service facility 2-2

Service header 1-72

Service life 7-12, 7-13

Service magazine 20, 26

Service piping 13-14, 13-16, 13-33, 15-16

Service water 15-1, 15-16, 15-18

Serviceability 1-89

Severe natural phenomena 1-97, 1-98, 13-12, 13-90, 13-102, 13-110, 13-115, 13-120, 13-125, 15-20, 15-45

Sewage 17, 1-33, 2-37, 2-50, 15-23

Sewer 14, 1-20, 1-21, 1-109, 2-15, 2-17, 2-31, 2-37-39, 2-42, 2-43, 2-57, 7-10, 7-13, 15-23, Shear 13-87

Shear 15-67

Shear seal 15-67

Sheet membrane waterproofing 7-3

Sheet metal 7, 1-46, 7-11, 7-12

Sheet metal flashing 7-12

Sheet metal roofing 7-11, 7-12

Sheet piling 26, 2-11

Shelter 20, 1-31, 1-54, 1-58, 1-78, 1-93

Shielded enclosure 1-78, 1-83

Shielding 1-17, 1-27, 1-58, 1-74, 1-76, 1-78, 1-82, 1-92, 9-3, 11-2, 11-3, 11-5, 12-1, 12-3, 13-8, 13-9, 13-34, 13-73, 13-77, 13-83, 13-117, 13-123, 15-45, 15-49, 15-51

Shielding design 1-76, 13-9, 15-49

Shock 13, 14, 15, 19, 1-78, 1-82, 1-85, 1-93, 1-96, 2-59, 15-70

Shock mount 1-78

Shoring 7, 26, 1-47, 2-11, 2-20, 2-38

Shower 1-19, 7-1, 7-4, 8-4, 9-3, 9-5, 10-1, 10-3, 10-4, 13-11, 13-39, 13-69, 15-18, 15-22, 15-41

Shrinkage 1-95, 1-96, 2-10, 7-2, 7-5

Shrubs 2-69, 2-70

Shutoff device 15-78

Sidewalk 26, 1-108, 2-16, 2-19, 2-54-56

Double-hyphen entries indicate inclusive pages e.g., "3-27-29" means page 3-27 through page 3-29.
Entries for singular words can include plurals.

Sign 1-14, 1-70, 1-84, 1-92, 2-28, 13-103, 15-19, 16-8

Simultaneous heating and cooling 15-78, 15-79

Single failure 26, 1-34, 13-6, 15-12, 15-20, 15-44, 16-18, 16-19

Single failure criterion and redundancy 13-6

Siphon breaker 13-8, 13-77, 13-86, 13-92, 13-98, 13-106

Site 7, 12, 13, 14, 15 16, 19, 20, 22, 25, 26, 27, 1-1-3, 1-10, 1-18, 1-23, 1-27, 1-29, 1-30, 1-36, 1-39, 1-54, 1-56, 1-61, 1-62, 1-65, 1-67, 1-68, 1-72, 1-86, 1-87, 1-92, 1- 93, 1-97-100, 1-103-106, 2-1-9, 2-11, 2-12, 2-14, 2-18-20, 2-24, 2-26, 2-28, 2-29, 2-31, 2-33, 2-35, 2-39-41, 2-43-45, 2-47, 2-52-59, 2- 61, 2-63-70, 8-2, 8-3, 8-7, 9-5, 10-2, 10-3, 13-3-5, 13-11, 13-15-17, 13-23-26, 13-28, 13-56, 13-64, 13-97, 13-105, 13-107-111, 14-1, 14-2, 15-3, 15-4, 15-11, 15-22, 15-27, 15-28, 15-48, 15-55, 15-59, 15-75, 16-1, 16-3, 16-5-9, 16-12, 16-13, 16-17, 16-22

Site access 2-65

Site analysis 2-68

Site approval 2-65

Site boundary 22, 26, 13-5, 13-15, 13-110

Site safeguards and security plan (SSSP) 7, 2-57, 13-20, 13-26

Site-specific safeguards 12, 27, 2-56, 13-17

Siting 20, 1-35, 2-1-4, 2-36, 2-58, 2-64, 13-18, 13-19, 13-62, 13-64, 13-66, 13-85, 13-105, 15-69

Siting design dose objectives 13-105

Sketch 2-14

Slab 28, 1-75, 1-89, 1-96, 2-10, 2-22, 3-4, 7-1-6, 13-13, 13-30, 15-22

Slanting 27, 1-58

Sleeve 7-3, 15-22, 15-23

Slope 28, 2-11, 2-19, 2-27, 2-56, 2-69, 7-3, 7-10, 7-11, 13-32, 15-23

Sludge 9, 20, 2-36, 2-43, 2-45, 2-47, 13-50, 13-81, 13-86, 13-96, 13-98

Slurry 2-11, 15-22, 15-23, 15-51

Smoke 1-21, 1-108, 13-6, 15-1, 15-10, 15-14, 15-29, 15-38, 15-40, 15-68, 15-72, 15-73, 15-77, 15-80, 15-83

Smoke detector 15-10, 15-73

SNM vault 27, 1-86, 13-20

Soil 2, 7, 9, 10, 11, 16, 20, 25, 27, 1-14, 1-23, 1-37, 1-45, 1-94, 1-96, 1-103-106, 1-109, 2-1, 2-4, 2-9-12, 2-19-22, 2-29, 2-32, 2-35, 2-38-41, 2-45, 2-47, 2-48, 2-58, 2-60, 2-64-66, 2-68-70, 7-2, 7-5, 7-13, 13-100, 13-104, 13-107, 13-108, 15-17, 15-61, 15-65, 16-7

Soil cover 2-65

Soil erosion 1-105, 1-106, 2-40, 7-13

Soil mechanics 27

Soil resistivity 27

Solar 1-61, 1-64, 1-67, 2-68, 7-10, 10-4, 12-1, 15-33, 15-34

Sole-source 2-64

Solid waste 7, 17, 20, 21, 1-5, 1-8, 1-57, 1-105, 2-36, 2-63-68, 13-2, 13-14, 13-49, 13-56, 13-61, 13-75, 13-80, 13-85, 13-91, 13-96, 13-104-111, 13-115, 13-120, 13-126, 15-24, 15-25, 15-51

Solvent 13-50, 13-81, 13-88, 13-94-96, 13-115, 13-121, 13-126, 15-12, 15-17, 15-51, 16-23

Sound transmission classification (STC) 7, 1-88, 1-89

Sound transmission class 1-23

Source material 27

Space heating 1-61, 15-31, 15-34, 15-83, 16-28

Space requirement 20, 1-78, 15-63

Spandrel 7-4, 7-5

Sparging 13-30-32

Spark-resistant 15-38

Special applications 15-39, 15-65

Special coating 9-7

Special isotope separation laser (SISL) 7, 1-30

Special nuclear materials (SNM) 7, 24, 25, 27, 1-74, 1-86, 1-87, 2-57, 2-61, 11-5, 13-8, 13-14, 13-16-25, 13-28, 13-29, 13-50, 13-54, 13-59, 13-117, 16-24, 16-25

Speed bump 2-56

Spike 2-25, 13-31

Spill 7, 9, 2-47, 2-48, 13-3, 13-11, 13-15, 13-78, 13-93, 13-101, 15-69, 15-70, 16-8

Spill prevention control and countermeasure (SPCC) 7, 2-48, 16-8

Sprinkler 1-38, 1-57, 1-90, 2-34, 2-70, 7-3, 12-3, 13-7, 13-71, 13-88, 15-3-7, 15-9-14, 16-23

Staging bays (in-process) 27, 13-68

Stairway 9-2, 9-3

Double-hyphen entries indicate inclusive pages, e.g., “3-27-29” means page 3-27 through page 3-29.
Entries for singular words can include plurals.

Staking 2-12, 2-16

Standard Operating Procedures (SOP) 7, 13-63

Standby 27, 29, 1-34, 1-40, 1-86, 2-61, 2-62, 13-10, 13-71, 15-31, 15-36, 15-46, 15-55, 15-70, 16-14-17

Standpipe 1-24, 1-38, 5-2, 15-10, 15-8

Start-up 2-45, 2-62

State 1, 1-1, 1-2, 1-8, 1-9, 1-13, 1-14, 1-33, 1-41, 1-58, 1-59, 1-104, 1-105, 2-11, 2-14, 2-23, 2-25, 2-28, 2-33, 2-41, 2-43, 2-44, 2-46, 2-48-50, 2-66, 2-70, 13-15, 13-22, 13-30, 13-36, 13-50, 13-74, 13-88, 15-27, 15-35, 15-43, 15-67, 15-71, 15-74-76, 16-13, 16-17, 16-19

State commission 2-23

Static electricity 1-82, 9-7, 16-23

Statute 25, 2-11

Steam 1-9, 1-22, 1-31, 2-50, 13-72, 13-94, 15-32, 15-34, 15-35, 15-37, 15-38, 15-43, 15-54-61, 15-64, 15-65, 15-82, 15-83, 16-5, 16-17, 16-23

Steel 1, 4, 5, 7, 23, 26, 27, 1-16, 1-19, 1-21, 1-22, 1-24, 1-28, 1-35, 1-36, 1-45-47, 1-70, 1-87, 1-101, 2-12, 2-32, 2-48, 2-53, 2-59, 4-2, 5-1-3, 8-2-4, 8-6, 9-3, 13-21, 15-17, 15-35-37, 15-60, 15-66-68, 15-74, 16-2, 16-7

Steel conduit 16-2, 16-7

Steps 1-64, 1-71, 13-30, 13-78, 13-93, 15-35, 16-23

Sterilization 1-108, 15-19

Storage 4, 6, 8, 9, 11, 12, 15, 16, 18, 19, 20, 21, 22, 26, 27, 29, 1-5, 1-7, 1-9, 1-17-19, 1-24, 1-25, 1-39, 1-42, 1-52, 1-55, 1-72, 1-74, 1-79, 1-81, 1-82, 1-84-86, 1-93, 1-103, 2-7, 2-8, 2-31, 2-32, 2-44, 2-47, 2-50, 2-51, 2-53, 2-68, 5-2, 7-4, 7-8, 8-3, 8-6, 9-2, 9-5, 11-3, 12-2, 13-2, 13-8, 13-9, 13-11, 13-13, 13-14, 13-16, 13-21, 13-24, 13-26-28, 13-37, 13-39, 13-43, 13-45, 13-47, 13-51-62, 13-66, 13-68, 13- 70, 13-72, 13-76, 13-81-85, 13-91, 13-94, 13-97-107, 13-109, 13-110, 13-116, 13-117, 13-120-124, 13-126, 15-6, 15-10, 15-13-16, 15-20, 15-21, 15-24, 15-26, 15-27, 15-34, 15-35, 15-44, 15-51, 15-53, 15-55, 15-58, 15-59, 15-63, 15-66, 15-68, 15- 69, 15-72, 15-74, 15-75, 16-9, 16-21, 16-24

Storage area compartment 27

Storage battery 1-84, 15-53

Storage facility 4, 6, 8, 12, 21, 22, 1-5, 1-24, 1-74, 2-31, 2-32, 13-2, 13-51, 13-53, 13-57, 13-59, 13-76, 13-81-83, 13-97, 13-105, 13-106, 13-116, 13-121-123, 13-126, 15-24, 15-72, 15-75

Storage vessel 13-85, 13-100-103, 13-117, 13-126, 15-21, 15-66, 15-69

Storm 21, 23, 29, 1-14, 1-21, 2-17, 2-39-43, 2-45, 2-57, 2-60, 7-10, 7-12, 7-13, 8-4, 8-6

Storm door 1-14, 8-4, 8-6

Storm sewer 1-21, 2-42, 2-57, 7-10, 7-13

Stormwater 12, 17, 1-104, 1-106, 2-17, 2-19, 2-37, 2-39, 2-40, 2-42, 2-44, 2-57

Stove 10-2

Stream 20, 24, 2-39, 2-40, 2-43, 2-47, 13-15, 13-31, 13-71, 13-73, 13-75, 13-98-100, 15-5, 15-38, 15-44, 15-45, 15-49, 15-50, 15-76

Street 23, 26, 1-12-14, 1-16, 1-18, 1-19, 1-21, 1-22, 1-28-31, 1-34-36, 1-38, 1-44, 1-49, 1-50, 2-17, 2-24, 2-26, 2-27, 2-42, 2-43, 2-55, 10-2

Structural 10, 25, 27, 28, 29, 1-14-16, 1-21, 1-24, 1-28, 1-53, 1-54, 1-74, 1-75, 1-85, 1-89, 1-90, 1-92-98, 1-100, 1-101, 2-8-10, 2-20, 2-23, 2-48, 2-59, 3-1, 3-3, 3-4, 4-1, 5-1-3, 6-1, 7-3, 7-6, 7-10, 7-12, 9-3, 9-4, 11-1-3, 13-9, 13-13, 13-53, 13-55, 13-59, 13-61, 13-65-67, 13-82, 13-85, 13-121, 15-12, 15-64, 15-69, 15-74, 16-18

Structural collapse 27, 13-66, 13-67

Structural steel 1-16, 5-1, 15-74

Subassembly 16, 18, 13-68

Subbase 27

Subcritical flow 28

Subgrade modulus (K) 4, 28, 1-13, 1-31, 15-17

Subslab 28, 7-2, 7-3

Substantial construction 28, 1-87

Substation 1-34, 2-52, 2-53, 16-5, 16-7, 16-8, 16-10, 16-21

Subsurface 10, 12, 1-96, 2-9, 2-10, 2-19-21, 2-42, 2-44, 2-58, 2-66

Subsurface conditions 1-96, 2-9, 2-10, 2-21

Sulfate 2-32

Sulfur dioxide (SO_2) 7, 15-73

Sump 13-86, 13-98, 13-102, 13-106, 13-108, 15-23, 15-24, 15-33, 15-70, 15-82

Sun control 10-4

Supercritical flow 28

Superelevation 28, 2-25, 2-26

Supervisory device 15-8

Supervisory system 15-83, 16-24, 16-28

Double-hyphen entries indicate inclusive pages, e.g., “3-27-29” means page 3-27 through pages 3-29. Entries for singular words can include plurals.

Supply 8, 12, 14, 16, 27, 29, 1-31, 1-71, 1-79, 2-31, 2-32, 2-35, 2-36, 2-38, 2-52, 2-61, 2-64, 2-70, 11-4, 11-5, 13-10, 13-11, 13-23, 13-25, 13-31, 13-40, 13-45, 13-84, 13-125, 15-4-6, 15-10-12, 15-16-22, 15-28, 15-29, 15-34, 15-37, 15-38, 15-47, 15-48, 15-50, 15-55, 15-58, 15-64, 15-65, 15-78-80, 15- 82, 15-83, 16-6, 16-8, 16-9, 16-11, 16-13, 16-14, 16-17, 16-21, 16-22, 16-24, 16-25

Supply air 13-84, 15-29, 15-37, 15-47, 15-78, 15-79

Supply equipment 16-6

Supply facility 16-24

Supply system 13-11, 15-4, 15-10, 15-19-21, 16-21

Support building 28, 13-66, 13-69

Support facility 13-73

Suppression system 1-56, 1-75, 11-4, 13-3, 13-53, 13-59, 15-2-5, 15-7, 15-11, 15-13, 15-14

Surface water resource 2-66

Surfacing 2-19, 2-26, 2-54

Surfactant 28, 1-105

Surge 2-35, 13-94, 15-32, 15-63, 16-8, 16-9, 16-22

Surveillance 14, 24, 1-11, 1-12, 1-28, 1-84, 1-85, 2-57, 2-61, 13-4, 13-7, 13-15, 13-20, 13-27-29, 13-42, 13-46, 13-50, 13-54, 13-102, 13-103, 13-118, 15-76

Survey 2, 5, 8, 10, 21, 1-13, 1-35, 1-37, 1-103, 1-108, 2-11, 2-12-16, 2-66

Survey monument 2-12-15

Surveying 1, 1-16, 1-108, 2-11-14

Switchgear 1-34, 16-6, 16-11

Switching 14, 27, 1-81, 1-110, 2-52, 13-42, 15-46, 15-52, 15-53, 16-7, 16-8, 16-10, 16-25

Switching center 1-81, 15-52

Switching station 2-52, 16-7, 16-8, 16-10

Symbol 2-10, 13-43

System protection 16-11

Systems integration 1-52, 16-27

Tactical response force 28, 2-8, 2-61

Tail 13-70, 13-73, 13-74, 13-76, 15-24

Tails processing area 13-73

Tamper indicating device (TID) 7, 13-29, 13-53, 13-59

Taxiway 2-30

Telecommunications 6, 10, 12, 1-5, 1-10, 1-43, 1-52, 1-78, 1-79, 1-81, 1-83, 1-84, 2-7, 2-9, 13-2, 15-13, 15-14, 15-52, 15-53, 16-9, 16-13-15, 16-24, 16-26, 16-27

Telephone 1-6, 1-75, 1-81, 1-86, 1-88, 1-105, 1-108, 2-15, 2-17, 10-4, 13-25, 13-42, 15-52, 16-24-27

Telephone switching center 1-81, 15-52

Teletype 1-81, 2-8, 15-52

Television (TV) 2, 8, 1-52, 1-69

Tempest 1-10, 16-27

Temporary control monument 2-12, 2-13, 2-15

Temporary facility 10, 1-1, 1-61, 1-106

Temporary security fencing 1-104, 1-106

Temporary utility 1-104, 1-105

Tension wire 28, 2-58, 2-59

Terminal unit 15-34, 15-35, 15-37, 15-81, 15-82

Tertiary confinement 13-47, 13-49, 13-55, 13-61, 13-90, 13-102, 13-103, 13-109, 13-110, 13-113, 13-115

Test 18, 19, 21, 28, 1-11, 1-23, 1-26, 1-27, 1-33, 1-37, 1-40, 1-46, 1-48, 1-49, 1-79, 1-81, 1-90, 1-102, 1-108-110, 2-9, 2-10, 2-22, 2-32, 2-39, 2-49, 2-61, 4-2, 9-7, 13-5, 13-7, 13-23, 13-35-37, 13-42, 13-63, 13-66, 13-68, 13-103, 13-116, 13-121, 15-1, 15-5, 15-21, 15-28, 15-33, 15-40-43, 15-45, 15-56, 15-68, 15-74, 16-1, 16-18, 16-20, 16-21

Testing 2, 6, 15, 16, 21, 1-17, 1-21, 1-22, 1-28, 1-39, 1-42, 1-56, 1-72, 1-84, 1-88, 1-89, 1-93, 1-100, 1-104, 1-108, 1-110, 2-3, 3-2, 3-3, 7-9, 8-1, 8-3, 10-2-4, 12-3, 13-6, 13-7, 13-37, 13-42, 13-47, 13-48, 13-72, 13-83, 13-103, 13-112, 13-123, 15-19, 15-22, 15-28, 15-33, 15-38, 15-39, 15-41, 15-42, 15-46, 15-47, 15-49, 15-70, 15-74, 16-1, 16-17, 16-18, 16-20, 16-25

Tetrachlorodibenzo-p-dioxin (TCDD) 7

Theft 1-68, 1-104, 1-106, 13-16-20, 13-25-28

Thermal 2, 3, 7, 17, 1-8, 1-21, 1-48, 1-60, 1-61, 1-63-65, 1-91, 1-94, 1-96, 7-1, 7-6, 7-7, 8-1, 13-31, 13-63, 13-94, 13-107, 15-17, 15-25, 15-27, 15-30, 15-31, 15-34, 15-41, 15-61, 15-66, 15-67, 15-70, 15-75

Threshold limit value (TLV) 7, 1-15, 15-29, 15-71

Through-the-wall flashing 7-1, 7-4, 7-5

Tie 9, 2-24, 2-25, 2-27, 4-2, 7-7, Tie plate 2-24

Tile 7, 29

Tile 1-23, 1-33, 1-47, 4-1, 7-9, 7-12, 9-3, 9-4, 13-42

Title I 1-52, 1-54, 1-56, 1-60, 1-66, 1-67, 1-102, 1-104, 15-62

Title II 1-54, 1-67, 1-102, 15-62

TNT 28, 13-69

TNT equivalent 28, 13-69

Toilet 1-6, 9-3, 10-4, 10-5, 15-26

Topography 2-18, 2-29, 2-39, 2-41, 2-69

Tornado 3, 13, 1-31, 1-36, 1-54, 1-75, 1-91-93, 1-97-99, 2-2, 13-49, 13-55, 13-61, 13-68, 13-85

Total estimated cost (TEC) 7, 1-67

Tower 2, 1-21, 1-26, 1-28, 1-86, 1-92, 2-61, 2-62, 5-2, 7-10, 13-11, 13-25, 13-26, 13-72, 15-3, 15-27, 15-31, 15-33, 15-69, 15-74, 15-82, 16-9, 16-10, 16-21, 16-27

Toxic material 30, 1-53, 15-39, 15-71

Toxicity 1-76, 2-47, 13-77, 13-114, 15-50

Track layout 2-23

Traffic 1-14, 1-18, 1-71, 1-74, 1-75, 1-86, 1-103, 1-106, 2-4, 2-12, 2-25, 2-26, 2-28, 2-32, 2-35, 2-38, 2-39, 2-42, 2-44, 2-49, 2-54-56, 2-58, 2-59, 2-65, 8-5, 11-5, 13-25, 13-37, 13-53, 13-59, 13-64, 14-2, 16-15, 16-21, 16-22

Traffic control 1-18, 1-74, 1-103, 2-28, 2-54-56, 13-25, 13-53, 13-59

Transfer pipe 13-13, 13-56

Transfer system 2-50, 11-3, 13-29, 13-33, 13-50, 13-56, 13-72, 13-77, 13-92, 13-99

Transformer 1-32, 1-35, 15-3, 16-8, 16-11-13, 16-22

Transient 28, 29, 1-69, 2-57, 13-21, 13-67, 15-24, 16-11

Transition coupling 15-68

Transmission 7, 10, 23, 1-21, 1-23, 1-64, 1-79, 1-80, 1-83, 1-84, 1-89, 1-94, 2-17, 2-59, 5-2, 8-1, 13-24, 15-8, 15-13, 15-14, 15-37, 15-53, 16-6, 16-21, 16-25-27

Transmission line 1-79, 1-84, 2-59, 13-24, 16-21, 16-26, 16-27

Transmission pole structure 1-21, 5-2

Transmission tower 1-21, 5-2

Transmitter 1-84, 15-52, 15-73, 15-77, 16-14

Transportation 1, 3, 10, 18, 1-11, 1-14, 1-18, 1-25, 1-30, 1-52, 1-97, 1-100, 2-5, 13-31, 13-51, 13-55, 13-57, 13-61, 13-85

Transporting 1-15, 3-3, 13-28

Transuranic (TRU) 7, 17, 20, 28, 1-8, 11-3, 13-14, 13-44, 13-49, 13-51, 13-73, 13-97, 13-98, 13-100, 13-101, 13-103-106, 13-109

Transuranic elements 28, 13-51

Transverse 28

Trap seal 15-19

Treatment, storage and disposal (TSD) 8, 1-9, 2-44, 2-63-67, 13-4

Tree 1-92, 2-13, 2-18, 2-68-70

Trench 1-84, 2-17, 2-38, 2-45, 2-52, 2-64, 2-65, 15-60, 15-74, 16-26

Trim 7-12

Tritium 21, 1-5, 9-2, 13-2, 13-113, 13-116-127, 15-16

Trouble signal 15-8

TRU waste 17, 20, 28, 13-49

Tsunami 2-6

Tube 2, 1-23, 1-41, 15-33, 15-35, 15-41-43

Tubing 3, 15-17, 15-67, 16-2

Turf 2-69, 2-70

Turnouts 2-25, 2-60

Ultra high frequency (UHF) 8, 16-27

Unattended opening 29, 1-70

Uncased explosive 13-68

UNCI 1-47

Underground 11, 20, 1-9, 1-48, 1-86, 2-15-18, 2-32, 2-49, 2-52, 2-68, 13-100, 13-102, 15-1, 15-10, 15-17, 15-35, 15-60, 15-61, 16-2, 16-7, 16-9, 16-21, 16-22, 16-24, 16-27

Underpinning 29, 2-11, 2-20

Uninterruptible power supply (UPS) 8, 14, 29, 1-109, 2-61, 13-10, 13-46, 15-47, 16-11, 16-14, 16-16-18

Unirradiated enriched uranium (UEU) 8, 21, 29, 1-5, 1-76, 13-2, 13-57, 13-58, 13-60, 13-61, 13-78, 13-81, 13-97

Unirradiated enriched uranium storage facility (UEUSF) 8, 21, 1-5, 13-2, 13-57-62, 13-81, 13-97

Unit hydrograph 29

Unit masonry 29, 1-22, 4-1, 4-2

Double-hyphen entries indicate inclusive pages, e.g., "3-27-29" means page 3-27 through page 3-29. Entries for singular words can include plurals.

Unit process area (UPA) 8, 13-32

Unit weight 1-90

Unpackaging 16, 29, 13-45, 13-52, 13-58

Unpackaging room 29, 13-52, 13-58

Unproven facility design 13-66

Unsprinklered 15-5

Uranium conversion and recovery facility (UCRF) 8, 1-5, 13-2, 13-92-96, 15-15

Uranium dioxide (UO_2) 8, 13-76, 13-92

Uranium enrichment area 13-73

Uranium enrichment facility (UEF) 8, 1-5, 13-2, 13-69, 13-70, 13-74-76, 15-14, 15-24

Uranium hexafluoride (UF_6) 8, 1-42, 13-71-76, 13-92, 13-94, 15-14, 15-24, 15-49

Uranium processing and handling facility (UPHF) 8, 1-5, 13-2, 13-76-78, 13-80, 13-81, 13-92

Uranium recovery facility (URF) 8, 13-92-94

Uranium tetrafluoride (UF_4) 8, 13-72

Uranium trioxide (UO_3) 8, 13-92

Usability 13-44

Useful life 29, 1-102, 15-46

User group 2-8

Utility 6, 11, 16, 28, 1-10, 1-30, 1-53, 1-59, 1-64, 1-72, 1-74, 1-81, 1-84, 1-85, 1-103-105, 1-108, 2-2, 2-4, 2-5, 2-7, 2-15-18, 2-29, 2-31-34, 2-37-39, 2-52, 2-56-58, 2-64, 2-67-69, 9-2, 9-5, 13-68, 13-69, 13-81, 13-91, 13-97, 13-121, 13-126, 15-10, 15-22, 15-39, 15-53, 15-56, 15-83, 16-5-7, 16-9, 16-12, 16-13, 16-22, 16-25

Utility corridor 2-31, 2-33, 2-37, 16-6

Utility location 2-17

Utilization schedule 1-73

Vacuum 1-108, 2-35, 13-10, 13-87, 13-102, 13-123, 13-124, 15-18, 15-19, 15-51, 15-52, 15-66, 15-68, 15-70

Vacuum breaker 15-18, 15-19

Vacuum seal 15-68

Valve 6, 1-22, 1-72, 1-90, 1-108, 2-15, 2-34, 2-35, 2-48, 13-32, 13-39, 13-118, 13-119, 15-6, 15-8, 15-10, 15-11, 15-15, 15-17-19, 15-21-23, 15-32, 15-35-37, 15-43, 15-46, 15-48, 15-58, 15-60, 15-61, 15-67, 15-68, 15-81, 15-82, 16-22

Valving 15-4, 15-10

Vapor retarder 7-6

Vaporizer 15-65

Variable-air-volume 15-38, 15-79

Variable speed 15-32, 15-36, 15-81

Vault 27, 29, 1-5, 1-32, 1-48, 1-74, 1-81, 1-86, 1-87, 13-2, 13-20, 13-21, 13-23, 13-27-29, 13-53, 13-54, 13-59

Vault-type room 29, 1-5, 1-86, 1-87, 13-2, 13-20, 13-21, 13-23

Vector 25, 29, 2-65

Vegetation 2-58, 2-68, 2-69

Vehicle 20, 1-68-70, 1-85, 1-105, 2-5, 2-19, 2-54-56, 2-58-62, 2-65, 2-69, 7-13, 13-20-22, 13-28, 13-29

Vehicle barrier 2-59-61, 13-21

Vehicular 1-69, 1-70, 1-86, 1-103, 1-106, 2-12, 2-42, 2-49, 2-53-55, 2-58, 2-59, 2-62, 2-63, 2-65, 13-21

Veneer 1-33, 9-4

Veneer plaster 1-33, 9-4

Vent 10-1, 13-30, 13-75, 13-79, 13-87, 13-89, 13-91, 13-100, 13-103, 13-104, 13-109, 13-111, 13-113, 13-119-121, 13-126, 15-16, 15-17, 15-36, 15-48-50, 15-61, 15-74, 15-76

Ventilating 4, 9-1, 15-25, 15-30, 15-31, 15-52, 15-53, 15-77

Ventilation 11, 1-14, 1-21, 1-40, 1-42, 1-62-64, 1-66, 1-67, 1-71, 1-73, 1-74, 8-2, 11-1, 11-2, 11-4, 11-5, 13-7, 13-9, 13-10, 13-12-14, 13-33, 13-34, 13-38, 13-45-50, 13-54, 13-55, 13-57, 13-60-62, 13-66, 13-68, 13-74, 13-75, 13-77, 13-79, 13-80, 13-84, 13-85, 13-87-90, 13-95, 13-96, 13-101, 13-109, 13-110, 13-112-115, 13-119, 13-120, 13-125, 13-126, 14-2, 15-12, 15-13, 15-27-31, 15-37-40, 15-42, 15-44-48, 15-50, 15-52, 15-53, 15-70, 15-71, 15-74-80

Ventilation and off-gas criteria 15-42

Vertical control 10, 1-108, 2-12, 2-14, 2-27, 2-28

Vertical transportation 1-52

Very high frequency (VHF) 8, 16-27

Vibration 30, 1-13, 1-82, 1-85, 1-96, 1-108, 2-7, 2-23, 13-30, 13-31, 13-38, 13-73, 15-37, 15-63, 16-2, 16-27

Vibratory 13, 1-94, 2-6

Vine 2-69

Vinyl floor 1-82

Double-hyphen entries indicate inclusive pages, e.g., “3-27-29” means page 3-27 through page 3-29. Entries for singular words can include plurals.

Vital 11, 29, 1-11, 1-55, 1-68-70, 1-82, 1-93, 13-17-23, 13-35, 13-38, 15-2, 15-3, 15-11, 15-32, 15-54, 16-16

Vital area 29, 1-68-70, 13-17-20, 13-22, 13-23, 13-38

Vital equipment 29, 1-11, 1-69, 13-17-21, 13-23

Vital facility 29, 1-55

Vital program 29, 15-2, 15-32, 15-54

Volatile 9-2, 12-1, 13-48, 13-79, 15-68, 15-72, 15-75

Voltage 1-18, 1-110, 2-7, 2-8, 2-59, 13-122, 16-1, 16-4, 16-5, 16-9, 16-11-14, 16-17, 16-25

Wainscot 9-3

Waiver 1-3, 1-6, 1-60, 1-65, 13-63

Walk 16, 2-26, 2-54, 2-55, 14-1

Walkway 2-59, 2-60, 7-8, 7-10, 15-69

Wall 10, 22, 23, 24, 27, 29, 1-24, 1-33, 1-44, 1-56, 1-57, 1-61, 1-63, 1-66, 1-67, 1-69, 1-72, 1-75, 1-82, 1-84-89, 1-94, 2-8, 2-11, 2-56, 2-57, 2-62, 4-1, 4-2, 7-1-9, 7-12, 8-1-4, 8-7, 9-1-3, 9-5-8, 13-9, 13-13, 13-21, 13-25-27, 13-33, 13-34, 13-47, 13-51, 13-73, 13-100, 13-108, 13-123, 13-126, 15-3, 15-10, 15-16, 15-19, 15-22, 15-40, 15-51, 16-25

Wall covering 1-44, 9-2, 9-7, 9-8

Wall hose outlet 15-19

Warehouse 18, 15-26, 15-28

Warning 13-10, 13-11, 13-13, 13-41, 13-42, 13-53, 13-59, 13-103, 15-13, 16-8

Warning and annunciator system 13-41

Warning and alarm system feature 13-11

Waste 4, 5, 7, 8, 10, 17, 20, 21, 24, 25, 28, 1-5, 1-7-9, 1-11, 1-12, 1-42, 1-57, 1-71, 1-73, 1-105, 2-4, 2-18, 2-36, 2-44-51, 2-63-68, 2-70, 13-2, 13-7, 13-14-16, 13-30, 13-33, 13-45, 13-49-51, 13-56, 13-61, 13-62, 13-75, 13-80-82, 13-84, 13-85, 13-91, 13-93, 13- 96-111, 13-114-116, 13-120, 13-126, 15-16, 15-17, 15-21-25, 15-30, 15-46, 15-50, 15-51, 15-59, 15-71, 15-75, 15-83

Waste disposal 1-71, 13-107, 13-108, 13-110, 13-111

Waste heat 15-30, 15-83

Waste Isolation Pilot Plant (WIPP) 8, 28, 11-3, 13-105

Waste management 1-8, 1-11, 1-12, 2-46, 2-66, 13-14-16, 13-49, 13-56, 13-61, 13-97, 13-105, 13-106, 13-109

Waste product 20, 2-36

Waste segregation 13-14

Waste treatment 10, 25, 1-9, 1-42, 2-47, 2-50, 13-56, 13-84, 13-99, 13-111

Wastewater 9, 14, 19, 20, 24, 1-20, 1-29, 1-49, 1-57, 1-104, 1-106, 2-17, 2-19, 2-36-39, 2-43-47, 2-50, 13-14, 13-16, 15-23

Water 2, 3, 4, 5, 7, 8, 9, 10, 12, 16, 17, 18, 19, 20, 22, 24, 25, 26, 30, 1-8-10, 1-19, 1-23, 1-24, 1-26-28, 1-31, 1-38, 1-39, 1-41, 1-42, 1-44, 1-49, 1-50, 1-57, 1-62-67, 1-94, 1-103-106, 1-108, 1-109, 2-2, 2-6, 2-10, 2-15, 2-17, 2-31-36, 2-38, 2-42, 2-43, 2-45-48, 2-53, 2-64, 2-66-68, 2-70, 5-2, 7-1-7, 7-10, 7-12, 9-5, 11-2, 11-4, 13-7, 13-8, 13-14, 13-16, 13-45, 13-50, 13-71-73, 13-82-86, 13-88, 13-102, 13-106-108, 13-111, 13-118, 13-121, 13-126, 15-1, 15-3-12, 15-14-24, 15-27, 15-31-36, 15-38, 15-40, 15-42, 15-43, 15-51, 15-55-61, 15-64, 15-71, 15-75, 15-81, 15-82, 16-15, 16-21

Water chiller 15-32

Water collection 13-111, 15-21

Water demand 2-33, 15-5, 15-6

Water distribution 2-33, 2-34, 15-10, 15-31, 15-33, 15-35, 15-36, 15-42, 15-55, 15-60, 15-81

Water flow 2-53, 7-12, 15-4, 15-10, 15-32, 15-38, 15-42, 15-60, 15-81

Water hammer 30, 2-35, 15-17

Water level 2-6, 7-1, 13-82, 15-8, 15-60

Water pollution 4, 8, 1-9, 1-49, 1-57, 1-106, 2-43, 2-46, 13-14, 13-16

Water retention 7-10

Water spray 1-38, 15-7, 15-40

Water storage 12, 1-24, 2-31, 15-10,

Water supply 12, 2-31, 2-32, 2-36, 2-38, 2-64, 2-70, 15-4, 15-5, 15-6, 15-10, 15-12, 15-18, 15-20-22, 15-34

Water tank 1-39, 2-32, 5-2

Water treatment 1-24, 1-28, 1-41, 2-35, 2-36, 15-19, 15-33, 15-36, 15-59

Waterproofing 28, 1-16, 1-24, 1-38, 1-43, 7-1-6, 7-8, 7-10, 7-11, 9-7

Waterway 2-5

Weapons storage 13-26

Weather 1-15, 1-41, 1-49, 1-63, 1-64, 1-86, 2-11, 2-29, 2-40, 2-41, 2-60, 2-62, 2-65, 2-67, 3-3, 7-13, 8-5, 15-26, 15-28, 15-33

Weatherstripping 8-1

Double-hyphen entries indicate inclusive pages, e.g., “3-27-29” means page 3-27 through page 3-29. Entries for singular words can include plurals.

Welded joint 15-23, 15-41, 15-67

Welding 2, 1-23, 1-24, 5-3, 15-33, 15-70

Wells 2-4, 2-38, 2-67, 13-102

Wet pipe 15-6, 15-14

Wetland 1-8, 1-12, 2-2, 2-51, 2-52, 2-64

Wheelchair 2-16, 14-1, 14-3

Wheelchair lift 14-1, 14-3

Wind 3, 29, 1-31, 1-36, 1-47, 1-54, 1-61, 1-91, 1-92, 1-96-99, 1-105, 2-2, 2-6, 2-29, 2-30, 2-44, 2-53, 2-57, 2-68, 7-9, 7-11, 8-3, 13-11, 13-68, 13-101, 15-55

Wind load 1-92, 8-3

Window 6, 7, 29, 1-14, 1-18, 1-39, 1-43, 1-44, 1-47, 1-48, 1-61, 1-63, 1-70, 1-78, 1-81, 1-84-88, 2-62, 2-69, 7-8, 7-10, 8-1-4, 8-6, 8-7, 9-5, 11-2, 11-3, 12-1, 13-26, 16-3

Wire 2, 28, 1-20, 1-22, 1-70, 1-86, 1-109, 2-53, 2-58, 2-59, 8-1, 8-2, 8-4, 8-7, 16-3, 16-4, 16-23

Wiring 1-81, 1-105, 2-18, 2-52, 13-23, 15-15, 16-2, 16-20, 16-21, 16-24, 16-25

Wood 6, 26, 1-43, 1-44, 2-53, 6-1, 8-3-6, 9-3, 15-33

Wood structure 6-1

Work environment 19, 30, 13-34

Work space 1-59, 1-74, 8-5, 11-1, 12-3, 13-34

Workstation 1-59

Yard hose outlet 15-19

Yield strength (fy) 4

Zeolite 13-91

Zone 14, 19, 25, 1-71-73, 1-83, 1-84, 1-87, 1-103, 1-106, 2-4, 2-18, 2-34, 2-45, 2-54, 2-58, 2-59, 2-64, 2-66, 13-24, 13-28, 13-37, 15-8, 15-27, 15-61, 15-72, 15-77, 15-78, 15-81-83, 16-7, 16-19, 16-25, 16-26

Zone control 15-81, 15-82

Zoning 1-1, 2-67, 15-77

Double-hyphen entries indicate inclusive pages. e.g., "3-27-29" means page 3-27 through page 3-29. Entries for singular words can include plurals.

Referenced Documents Index

10 CFR 20 1-7, 13-106

10 CFR 60 1-7, 13-105

10 CFR 61 1-7, 13-105

10 CFR 72 1-7, 13-83

10 CFR 435 1-7, 15-83

10 CFR 436 1-7, 1-62

10 CFR 1022 1-8, 2-51, 2-52

16 CFR 1630 1-8, 12-3

29 CFR 1910 21, 1-8, 1-55, 9-5, 13-11, 14-1, 15-29, 15-30, 16-8

29 CFR 1926 1-8, 1-55, 2-20, 2-38, 9-5, 14-1

36 CFR 800 1-8, 1-104

40 CFR 61 1-8, 13-15, 13-50

40 CFR 112 1-8, 16-8

40 CFR 122 1-8, 2-48, 2-67

40 CFR 125 1-8, 1-41

40 CFR 141 1-8, 2-31, 2-33, 13-110

40 CFR 142 1-8, 2-31, 2-33

40 CFR 191 1-8, 13-105

40 CFR 192 1-8, 2-67

40 CFR 240 1-8, 2-67

40 CFR 241 1-8, 2-67, 15-75

40 CFR 249 1-8, 3-1

40 CFR 256 1-8, 2-63, 2-67

40 CFR 260 1-8, 2-47, 2-63, 2-67, 15-75

40 CFR 261 1-8, 2-47, 2-67

40 CFR 262 1-8, 2-47, 2-67

40 CFR 263 1-8, 2-47, 2-67

40 CFR 264 1-9, 2-47-49, 2-63, 2-67, 13-14, 15-75

40 CFR 265 1-9, 2-47, 2-49, 2-67, 13-14

40 CFR 267 1-9, 2-67

40 CFR 270 1-9, 2-47

40 CFR 271 1-9, 2-47

40 CFR 280 1-9, 2-47-50

40 CFR 423 1-9, 15-58, 15-59

40 CFR 761 1-9, 1-55, 16-8

41 CFR 101 21, 27, 1-6, 1-7, 1-9, 1-59, 1-82, 8-7, 16-15

48 CFR 10 1-9, 11-1

49 CFR 101-19.6 1-9, 1-13, 1-48

45 FR 12746 1-12, 2-63

54 FR 20694 1-12

AA Aluminum Finishes for Architecture 9-7

AA Finishes for Aluminum in Building 9-7

AABC Volume A-82 15-42

AAMA 101 1-14, 8-4, 8-6

AAMA 800 1-14, 7-13

AAMA 1102.7 1-14, 8-4

AAMA 1002.10 1-14, 8-4, 8-6

AASHTO GD-2 1-14, AASHTO GD-2 2-54

AASHTO GDHS 1-14, 2-27, 2-54, 2-55

AASHTO GSDB 1-14, 1-94

AASHTO GU-2 1-14, AASHTO GU-2 2-54

AASHTO HB-13 1-14, 1-91, 1-92, 1-94-96, 3-1, 3-2, 5-2, 5-3, 6-1

AASHTO LTS-1 1-14, 5-3

Double-hyphen entries indicate inclusive pages, e.g., "3-27-29" means page 3-27 through page 3-29. Entries for singular words can include plurals.

AASHTO T 258 1-14

AASHTO T 258 2-22

ACGIH Industrial Ventilation Manual 11-1, 11-4, 11-5, 15-30, 15-37-40, 15-74, 15-75

ACGIH TLVs 15-29

ACI 207.1R 1-15, 3-5

ACI 207.4R 1-15, 3-5

ACI 211.1 1-15, 3-2

ACI 211.2 1-15, 3-3

ACI 304 1-15, 3-3

ACI 305R 1-15, 3-3

ACI 306R 1-15, 3-3

ACI 318 1-15, 2-21, 2-22, 3-1, 3-2, 13-9

ACI 336.2R 1-15, 2-22

ACI 336.3R 1-15, 2-22

ACI 347 1-15, 3-2

ACI 349 1-15, 1-101, 3-2, 13-9

ACI 350R 1-15, 3-1

ACI 352R 1-15, 3-2

ACI 503.4 1-15, 3-5

ACI 531 1-15, 4-1

ACI 531.1 1-15, 4-1

ACI 543R 1-15, 2-22

ACI 546.1R 1-15, 3-5

ACI Guide to the Use of Waterproofing, Dampproofing, Protective, and Decorative Barrier Systems 9-7

ACI SP-4 1-16, 3-2

ACI SP-66 1-16, 3-2

ACSM Horizontal Control as Applied to Local Surveying Needs 1-16, 2-12

AFM 88-29 1-49, 1-63, 15-27

AFWL-TR-74-62 1-49

AISC M011 1-16, 5-1, 5-3

AISC N690 1-16, 1-101

AISC S326 1-16, 5-1

AISI Manual for Structural Applications of Steel Cables for Buildings 5-2

AISI Specifications for the Design of Cold-Formed Steel Structural Members 5-1

AMCA Publication 99 15-37

AMCA Publication 201 15-38

AMCA Publication 261 15-37

AMCA Standard 210 15-38

AMCR/DARCOM 385-100 1-20

ANL/EES TM-264 1-17

ANL/EES TM-264 2-44, 2-46, 2-63

ANS 6.4 1-17, 13-9

ANS 6.4.2 1-17, 13-9

ANS 8 series 13-7

ANS 8.1 1-17

ANS 8.3 1-17, 13-8, 13-63

ANS 8.5 1-17

ANS 8.6 1-17, 13-52

ANS 8.9 1-17

ANS 8.10 1-17

ANS 8.12 1-18

ANS 8.15 1-18

ANS 8.17 1-18

ANS 8.19 1-18

ANSI A115 series 1-18, 8-7

ANSI A156 series 1-18, 8-7

ANSI A216.1 1-18, 8-6

ANSI A39.1 1-18, 8-3

ANSI A58.1 1-18, 1-90-92

ANSI C136 series 1-18, 2-60, ANSI C2 1-18

ANSI C2 14-1, 16-1, 16-6, 16-7, 16-10, 16-21, 16-24

ANSI C84.1 1-18, 16-1

ANSI D12.1 1-18

Double-hyphen entries indicate inclusive pages, e g., “3-27-29” means page 3-27 through page 3-29. Entries for singular words can include plurals.

ANSI D6.1 1-18, 1-103, 2-28, 2-53-55

ANSI N13.1 1-18, 13-10, 15-76

ANSI N16.1 1-18, 13-8, 13-117

ANSI N2.3 1-18, 13-11

ANSI N42.18 1-18

ANSI N512 1-18, 9-1, 9-2

ANSI Z88.2 1-19, 13-11

ANSI Z358.1 1-19, 15-18

API 650 1-19, 5-2

AREA Manual for Railway Engineering (Fixed Properties) 1-19, 1-90-92, 1-94, 1-95, 1-97, 2-23-26, 3-1, 3-2, 3-5, 5-2, 5-3, 6-1

ARI 410 1-19, 15-38

ARI 430 1-19, 15-37

ARI 450 1-19, 15-33

ARI 460 1-19, 15-33

ARI 520 1-19, 15-31

ARI 550 1-19, 15-31

ARI 590 1-19, 15-31

ARI 850 1-19, 15-39

ARI 1010 1-19, 15-17

ARMA Guide to Preparing Built-Up Roofing Specifications 7-6, 7-11

ARMA Recommended Performance Criteria for Roofing Membranes Using Polymer Modified Bituminous Products 7-11

ARMA Residential Asphalt Roofing Manual 7-9

ASCE 1978-1 1-21, 5-2

ASCE Manual 63 1-21, 6-1

ASHRAE Applications Handbook 15-25, 15-30, 15-31, 15-35, 15-66

ASHRAE Equipment Handbook 15-25, 15-30, 15-31, 15-35, 15-36, 15-38, 15-39, 15-75

ASHRAE Fundamentals Handbook 15-25-27, 15-30, 15-31, 15-35, 15-38, 15-40, 15-54, 15-60

ASHRAE Manual, Design of Smoke Control Systems for Buildings 15-80

ASHRAE Publication GRP 158 15-26

ASHRAE Refrigeration Handbook 15-25, 15-30

ASHRAE Standard 15 15-30, 15-32, 15-33

ASHRAE Standard 20 15-33

ASHRAE Standard 24 15-33

ASHRAE Standard 51 15-38

ASHRAE Standard 55 15-25

ASHRAE Standard 62 1-61, 15-27-29

ASHRAE Standard 90 1-60, 1-61, 1-63-66, 11-1, 15-1, 15-16, 15-27, 15-37, 15-41, 15-79, 16-15, 16-28

ASHRAE Standard 100 1-60, 1-64, 1-66

ASHRAE Systems Handbook 1-64, 15-25, 15-30, 15-31, 15-35, 15-36, 15-42, 15-80

ASME A17.1 1-22, 14-1, 14-2

ASME B16 series 1-22, 15-36

ASME B31.1 1-22, 15-36, 15-37, 15-60, 15-67, 15-68

ASME B31.3 1-22, 15-20, 15-67, 15-68, 15-70

ASME Boiler and Pressure Vessel Code 1-22, 13-5, 15-18, 15-20, 15-33, 15-56, 15-66, 15-68, 15-70

ASME N509 1-22, 15-39

ASME N510 1-22, 13-7, 15-39

ASME NQA-1 1-22, 1-101

ASME PTC 4.1 1-22, 15-56

ASTM A312 1-22, 15-67

ASTM B1 1-22, 16-3

ASTM C145 1-22, 7-2

ASTM C1036 1-23, 8-8

ASTM C270 1-22, 7-2

ASTM C55 1-22, 7-2

ASTM C62 1-22, 7-2

ASTM C71 1-22, 4-2

ASTM C90 1-22, 7-2

ASTM C635 1-23, 9-4

ASTM C636 1-23, 9-4

ASTM C840 1-23, 9-4

ASTM D1586 1-23, 2-9

ASTM D1587 1-23, 2-9

ASTM D2113 1-23, 2-9

ASTM D2488 1-23, 2-9

ASTM D3656 1-23, 8-3, 8-6

ASTM D4256 1-23, 9-2

ASTM D4546 1-23, 2-22

ASTM E84 1-23, 9-6

ASTM E413 1-23, 1-88, 1-89

ASTM E580 1-23, 9-4

ASTM E648 1-23, 9-6, 12-3

ASTM F693 1-23, 9-6

ASTM G46 1-23, 15-36

AWWA C652 1-24, 15-19

AWWA C5186 1-24, 15-19

AWS D1.1 1-24, 5-3

AWS D1.2 1-24, 5-3

AWS D1.3 1-24, 5-3

AWS D5.2 1-24, 5-3

AWWA D100 1-24, 5-2

AWWA Water Treatment Plant Design 2-36

BIA Building Code Requirements for Engineered Brick Masonry 4-1

BIA Dampproofing and Waterproofing Masonry Walls 7-1, 7-5

BOCA Basic/National Mechanical Code 15-30

CAA 2, 1-9, 1-24, 15-75

CERC Shore Protection Manual 2-2

CERCLA 2, 1-9, 1-25, 2-1

CGA Pamphlet G-4.1 15-70

CGA Pamphlet G-4.4 15-70

CGA Pamphlet P-1 15-69

CGA Pamphlet S-1.1 15-68

CGA Pamphlet S-1.2 15-68

CGA Pamphlet S-1.3 15-68

CONF-86-09116-1 1-27, 13-71

CRI Carpet Specifiers Handbook 9-6

CRI Standard for Installation of Textile Floor Covering Materials 9-6

CTI Bulletin ATC-105 15-33

CWA 3, 1-9, 1-26, 2-39, 2-43, 2-46

DM-7.03 1-37, 1-96

DOD 6055.9 16, 18-20, 23, 1-26, 13-64, 13-66, 16-21

DOE 1360.2A 1-10, 2-7

DOE 4300.1B 1-1, 1-10, 1-59, 2-1, 2-5, 13-64

DOE 4330.2C 1-10, 1-65, 2-5, 15-34, 15-55, 15-72

DOE 4700.1 1-10, 1-51, 1-52, 1-54, 1-56, 1-57, 1-101, 1-110

DOE 5100.4 1-10, 1-58

DOE 5300.1B 1-10, 1-81, 1-84, 2-9, 16-27

DOE 5300.2B 1-10, 1-79, 1-83, 2-7, 16-13, 16-26, 16-27

DOE 5300.3B 1-10, 1-82, 2-7, 16-13, 16-26, 16-27

DOE 5300.4B 1-10, 1-79, 1-80, 2-7, 16-13, 16-26, 16-27

DOE 5400 series, Radiation Protection of the Public and the Environment 22, 2-33, 13-4, 13-15, 13-16, 13-50, 13-56, 15-50, 15-76

DOE 5400 series, Radiological Effluent Monitoring and Environmental Surveillance 13-4, 13-15, 13-50, 15-76

DOE 5400.1 1-10, 2-43, 2-46, 13-15, 13-16, 13-98, 13-101, 13-103, 15-71, 15-76

DOE 5400.3 1-10, 13-14, 13-16

DOE 5440.1C 1-10, 1-57, 2-2, 2-3, 2-43, 2-46, 2-51, 15-71

DOE 5480 series 13-10, 13-14

DOE 5480.1B 1-11, 1-57, 2-43, 2-44, 2-46, 13-14, 15-69

DOE 5480.3 1-11, 13-51, 13-57

DOE 5480.4 1-11, 1-55, 1-57, 15-71

DOE 5480.5 16, 1-11, 1-76, 13-1, 13-7, 13-8

DOE 5480.6 1-1, 1-11, 2-3, 13-1, 13-57, 13-82

Double-hyphen entries indicate inclusive pages, e.g., “3-27-29” means page 3-27 through page 3-29. Entries for singular words can include plurals.

DOE 5480.7, 1-11, 1-55, 1-56, 1-75, 13-17, 15-2, 15-3, 15-60, 15-71, 15-72

DOE 5480.8, 1-11, 1-77

DOE 5480.10 1-11, 1-73, 13-38, 15-44

DOE 5480.11 9, 1-11, 1-73, 13-4, 13-9, 13-11 13-15, 13-82, 13-83, 13-106, 13-113, 15-49

DOE 5480.16 1-11

DOE 5481.1B 25, 1-3, 1-11, 1-54, 2-3, 13-4, 15-70

DOE 5500.1A 1-11, 1-53

DOE 5500.3 1-11, 1-53, 2-3

DOE 5630.11 1-11, 13-16

DOE 5630.12 1-11, 13-27

DOE 5630.13 1-11, 13-17

DOE 5632 series 1-11, 1-74, 1-80, 1-85, 1-86, 2-7, 2-18, 2-19, 2-23, 2-27, 2-31, 2-52, 2-53, 2-56, 2-57, 2-59, 2-61, 11-5, 13-14, 13-16, 13-21, 13-25, 13-51, 13-69, 16-26

DOE 5632.7, 1-11, 2-62

DOE 5633 series 1-11-12, 13-16

DOE 5633.2 1-11, 13-26

DOE 5633.3 1-12, 13-26, 13-29, 13-54, 13-59, 13-114

DOE 5633.4 1-12, 13-26

DOE 5636.3A 1-12, 1-69, 1-79, 8-2, 9-5, 9-6

DOE 5637.1 1-12, 1-79-81, 2-7, 13-32, 16-26

DOE 5700.6B 1-12, 1-101, 15-70

DOE 5820.2A 20, 28, 1-12, 2-46, 2-67, 13-14, 13-33

DOE Design Guide 1-28, 10-2

DOE/DNA TP-20-7 1-27, 13-68

DOE/EP/0035 1-27, 13-29

DOE/EP 0108 1-27, 1-78, 1-82, 2-7, 9-6, 10-2, 15-14, 16-14

DOE/EV 0051/1 1-27, 16-11

DOE/MA 0129 1-27, 2-1, 15-54

DOE Radiation Standards for Protection of the Public 1-28, 13-4

DOE Threat Statement 1-28, 13-16

DOE/TIC 11268 1-28, 1-101, 13-64

DOE/TIC 11603 1-28, 13-5

DOE TSCM Procedural Guide 1-28, 1-79, 1-88, 8-2, 9-5, 9-6

DOT approved 13-54, 13-72, 13-73, 13-76

Drew Chemical, Ameroid Engineer's Manual of Marine Boiler and Feed Water Treatment 2-36

Drew Chemical, Principles of Industrial Water Treatment 2-36

EIA 222-D 1-28, 5-2

EIMA Guideline Specification for Exterior Insulation and Finish Systems Class PB Type A 7-8

EIMA Guideline Specification for Exterior Insulation and Finish Systems Class PM Type A and B 7-8

EPA 430/9-75-002 1-29, 2-45

EPA 450/4-80-023 1-29, 15-73

EPA 450/4-81-003 1-29, 15-73

EPA 600/8-81-009 1-29, 15-73

EPA 625/1-77-009 1-29, 2-45

EPA 625/1-80-012 1-29, 2-45

EPA Project #17090 1-29, 2-45

EPA Radiation Protection Guidance to the Federal Agencies for Occupational Exposure 1-29

EPRI NP-3659 1-29, 13-39

ERDA 76-21 1-28, 13-85, 13-87, 13-112, 15-39, 15-40

Executive Order 11490 1-12, 1-58

Executive Order 11593 1-12, 1-104

Executive Order 11988 1-12, 2-51

Executive Order 11990 1-12, 2-51

Executive Order 12088 1-12, 15-71

FAA AC 150/5020-1 1-30, 2-29

FAA AC 150/5050-5 1-30, 2-28

FAA AC 150/5070-6A 1-30, 2-30

FAA AC 150/5210-6C 1-30, 2-30

FAA AC 150/5300-2D 1-30, 2-28, 2-29

FAA AC 150/5300-12 1-30, 2-30

FAA AC 150/5300-4B 1-30, 2-30

Double-hyphen entries indicate inclusive pages *e.g.*, "3-27-29" means page 3-27 through page 3-29. Entries for singular words can include plurals.

FAA AC 150/5320-5B 1-30, 2-30

FAA AC 150/5320-6C 1-30, 2-30

FAA AC 150/5325-5B 1-30, 2-29

FAA AC 150/5340-1E 1-30, 2-30

FAA AC 150/5390-2 1-30, 2-28, 2-29

FAI/83-9 1-30, 13-73

FCC Technical Report No. 37 1-31, 15-57

FCC Technical Report No. 44 1-31, 15-57

FCC Technical Report No. 51 1-31, 15-56, 15-58, 15-59

FCC Technical Report No. 57 1-31, 15-72

FCC Technical Report No. 69 16-17, 1-31

FCC Technical Report No. 71 1-31, 15-56

FEMA CPG2-17 1-31, 1-78

FEMA TR-83A 1-31, 1-93

FEMA TR-83B 1-31, 1-93

FEMA TR-87 1-31, 1-58

FGMA Glazing Manual 1-31, 8-8

FGMA Sealant Manual 1-31, 8-8

Fink and Beaty, Standard Handbook for Electrical Engineers 1-31, 16-5

FIPS PUB 94 1-32, 16-9, 16-14

FM 1-57 1-32, 1-55

FM 5-4/14-8 1-32, 16-8, 16-12

FM-approved 1-56, 7-9, 8-1, 8-3, 10-3

FM Approval Guide 15-80

FS AA-D-600B 1-32, 1-87

FS FF-P-110 1-32, 8-7

FS FF-P-001480 1-32, 8-7

FS W-A-450B 1-32, 1-87, 13-24, 16-24

FS W-C-596 1-32, 16-5

FS WW-P-541 series 1-32

FUA 1-9, 1-32, 15-55

FWPCA 4, 1-9, 2-43, 2-46

GA Manual of Gypsum Veneer Plaster 9-4

GSA-approved 1-87, 13-26

IAEA Safety Series No. 30 11-3

ICBO Report 4071 9-3

ICRP Report No. 26 2-3

IEEE 141 1-34, 16-4

IEEE 142 1-34, 16-10

IEEE 242 1-34, 16-6, 16-11

IEEE 308 1-34, 16-17

IEEE 379 1-34, 16-18

IEEE 384 1-34, 16-18

IEEE 399 1-34, 16-6

IEEE 446 1-34, 16-17

IEEE 493 1-34, 16-5, 16-6, 16-11

IEEE 602 1-34, 16-14

IEEE 739 1-34, 16-28

IEEE 80 1-34, 16-10

IEEE 837 1-34, 16-10

IEEE C37 series 1-34, series 16-6, 16-11

IEEE C37.91 1-35, 16-12

IES Lighting Handbook 2-60, 16-14, 16-15

ISDSI 102 1-35, 8-4

LA-10294-MS 1-35, 2-4

LBL-9143 1-35, 1-90, 1-93

MBMA Metal Building Systems Manual 5-1

Meister and Rabideau, Human Factors Evaluation in System Development 1-36, 13-35

MIL-P-43951 1-27, 8-7

MIL-STD-282 17, 1-27

MIL-HDBK-419 16-9, 1-27

MIL-HDBK-1004/4 1-27, 16-9

MIL-HDBK-1013/1 1-27, 2-62

Double-hyphen entries indicate inclusive pages, e.g., “3-27-29” means page 3-27 through page 3-29.
Entries for singular words can include plurals.

MIL-STD-1330 1-27, 15-70

MIL-STD-1472C 1-27, 13-37, 13-40-43

MIL-STD-1630 1-27, 15-70

MLSFA Steel Framing Systems Manual 9-3

NAAMM Metal Finishes Manual 9-7

NASA NHB 7320.1B 2-36

NASA SP-3072 15-70

NBS Handbook 135 1-62

NBS Technical Note 837 28, 2-57

NCEL UG-0010 1-37, 1-62

NCMA TR 75B 1-37, 4-1

NCMA Waterproof Coatings for Concrete Masonry 7-1, 7-4

NCMA Waterproofing Concrete Masonry Basements and Earth-Sheltered Structures 7-1, 7-4

NEMA ICS 1-38, 16-13

NEMA MG-1 1-38, 16-12

NEPA 1-9, 1-38, 2-2, 2-52, 5

NFPA 10 1-38, 15-8

NFPA 11 1-38 15-7

NFPA 11A 1-38, 15-7

NFPA 12 1-38, 15-7

NFPA 12A 1-38, 15-7

NFPA 12B 1-38, 15-7

NFPA 13 1-4, 1-38, 12-3, 15-5, 15-6, 15-10, 15-17

NFPA 14 1-38, 15-8

NFPA 15 1-38, 15-7

NFPA 16 1-38, 15-7

NFPA 16A 1-38, 15-7

NFPA 17 1-38, 15-7

NFPA 20 1-38, 15-10

NFPA 22 1-39, 2-31

NFPA 22 5-2, 15-10

NFPA 24 1-39, 2-31, 15-10

NFPA 30 1-39, 1-79, 2-32, 15-35, 15-72

NFPA 31 1-39, 15-72

NFPA 37 1-39, 16-17

NFPA 45 1-39, 11-4, 15-30, 15-40

NFPA 50 1-39, 15-69

NFPA 54 1-39, 2-31, 15-72

NFPA 58 1-39, 2-31

NFPA 68 1-39, 15-74

NFPA 70 1-38, 1-39, 14-1, 16-1-3, 16-5, 16-10-12, 16-16, 16-17

NFPA 71 1-39, 15-8, 16-24

NFPA 72A 1-39, 2-52, 15-8, 16-24, 16-28

NFPA 72B 1-39, 2-52, 15-8, 16-24, 16-28

NFPA 72C 1-39, 2-52, 15-8, 16-24, 16-28

NFPA 72D 1-39, 2-52, 15-8, 16-24, 16-28

NFPA 72E 1-39, 2-52, 15-8-10, 15-80, 16-24, 16-28

NFPA 72F 1-39, 2-52, 15-8, 16-24, 16-28

NFPA 72G 1-39, 2-52, 15-8, 16-24, 16-28

NFPA 72H 1-39, 2-52, 15-8, 16-24, 16-28

NFPA 75 1-39, 1-82, 2-7, 15-14, 16-14

NFPA 78 1-39, 16-9, 16-23

NFPA 80 1-39, 8-1, 8-3

NFPA 80A 1-39, 1-57, 2-5

NFPA 85A 1-40, 15-60, 15-72

NFPA 85B 1-40, 15-60, 15-72

NFPA 85D 1-40, 15-60, 15-72

NFPA 85E 1-40, 15-60, 15-72, 15-74

NFPA 85F 1-40, 15-72, 15-74

NFPA 85G 1-40, 15-72

NFPA 90A 1-40, 15-28, 15-29, 15-37, 15-40, 15-52, 15-80

NFPA 91 1-40, 15-28, 15-40, 15-80

NFPA 96 1-40, 15-40, 15-80

NFPA 99 1-40, 16-14

Double-hyphen entries indicate inclusive pages, e.g., "3-27-29" means page 3-27 through page 3-29. Entries for singular words can include plurals.

NFPA 101 1-40, 1-55, 1-68, 1-73, 1-74, 2-61, 7-9, 8-2, 8-3, 8-7, 9-1, 9-8, 12-1-3, 13-38, 13-53, 13-59, 14-1, 15-29, 15-77, 15-80, 16-15, 16-17

NFPA 110 1-40, 16-15-17

NFPA 232 1-40, 1-82

NFPA 255 1-40, 15-38

NFPA 403 1-40, 2-30

NFPA 407 1-40, 2-31

NFPA 409 1-40, 15-7

NFPA 496 1-40, 16-21

NFPA 1221 1-40, 16-24

NFPA 1410 1-40, 15-4

NHPA 5, 1-9, 1-40

NJ Standard 0108.01 1-41, 2-57, 2-61, 2-62

NOAA Atlas 2 1-41, 2-41

NOAA Manual NOS NGS 1 1-41, 2-12

NOAA Manual NOS NGS 3 1-41, 2-12

NOAA/National Weather Service Technical Paper No. 40 1-41, 2-41

NOAA NGS Special Publication 247 2-12

Nordell, Water Treatment for Industrial and Other Uses 1-41, 2-36

NPDES 5, 1-8, 1-41, 2-39, 2-44, 2-45

NRCA Construction Details 7-10, 7-12

NRCA Handbook of Accepted Roofing Knowledge 7-6, 7-8, 7-10, 7-11

NRCA Roofing and Waterproofing Manual 7-3, 7-6, 7-8, 7-10, 7-11

NRCA Steep Roofing Manual 7-9, 7-12

NSA NACSIM 5203 1-84, 16-2, 16-26

NSPC 6, 1-37, 1-43, 15-16, 15-17

NTIA Manual 1-43, 5-2

NUREG 0700 1-41, 13-37-43

NUREG CR-2496 1-41, 13-40

NUREG CR-3331 1-41, 13-35

NWWDA IS-1 1-43, 8-5

NWWDA IS-2 1-43, 8-6

NWWDA IS-3 1-43, 8-5

NWWDA IS-6 1-43, 8-5

NWWDA IS-7 1-44, 8-6

OMB Circular A-130 1-13, 1-82

PCA Clear Coatings for Exposed Architectural Concrete 9-7

PCA Effect of Substances on Concrete and Guide to Protective Treatment 9-7

PCA Painting Concrete 9-7

PCA Surface Treatments for Concrete Floors 9-7

PCI MNL-116 1-44, 3-3

PCI MNL-120 1-44, 3-3

PDCA Architectural Painting and Wall Covering Manual 9-7, 9-8

Powell, Water Conditioning for Industry 1-44, 2-36

PTI Post-Tensioning Manual 3-3

PURPA 6, 1-10, 1-45, 15-56

R.G. 3.10 1-42, 13-50

R.G. 3.12 1-42, 13-46

R.G. 3.13 1-42, 13-76

R.G. 3.14 1-42, 13-46, 13-88

R.G. 3.17 1-42, 13-46, 13-88

R.G. 3.18 1-42, 13-89

R.G. 3.20 1-42, 13-88

R.G. 3.22 1-42, 13-88

R.G. 3.27 1-42, 13-88

R.G. 3.32 1-42, 13-89

R.G. 3.33 1-42, 13-87

R.G. 3.34 1-42, 13-77, 13-93

R.G. 3.35 1-42, 13-45

R.G. 3.43 1-42, 13-52, 13-58

Double-hyphen entries indicate inclusive pages, e.g., "3-27-29" means page 3-27 through page 3-29
Entries for singular words can include plurals.

R.G. 3.49 1-42, 13-83

R.G. 3.54 1-42, 13-83

R.G. 8.8 1-42, 15-22

RCRA 7, 1-10, 1-45, 1-79, 2-1, 2-46, 2-63, 2-67, 13-14, 13-15, 15-75

RFCI Recommended Work Procedures for Resilient Floor Covering 9-6

SAND 87-1926 1-47, 2-57, 2-59, 2-61

SAND 87-1927 1-47, 2-57

SAND 87-1928 1-47, 2-57

SCS National Engineering Handbook 1-45, 2-41, 2-70

SDI 100 1-45, 8-4

SDI 108 1-46, 8-4

SDI-Publ. 25 1-45, 5-3

SDI-Publ. DDM01 1-45, 5-3

SDWA 7, 1-10, 1-46, 2-33, 2-43, 2-46

SJI Standard Specifications Load Tables and Weight Tables for Steel Joists and Joist Girders 5-3

SMA 2005 1-46, 8-4

SMA 3001 1-46, 8-4

SMACNA Architectural Sheet Metal Manual 7-12

SMACNA Energy Recovery Equipment and Systems Manual 15-30

SMACNA Fibrous Glass Duct Construction Standards 15-40

SMACNA HVAC Air Duct Leakage Test Manual 15-40

SMACNA HVAC Duct Construction Standards—Metal and Flexible 15-40

SMACNA HVAC Duct Design Manual 15-40

SMACNA Round Industrial Duct Construction Standards 15-40

SPRI Single Ply Roofing: A Professional's Guide to Specifications 7-11

SPRI Wind Design Guide for Ballasted Single Ply Roofing Systems 7-11

SPRI Wind Design Guide for Fully Adhered Single Ply Roofing Systems 7-11

SPRI Wind Design Guide for Mechanically Attached Single Ply Roofing Systems 7-11

SSFI SH 300 2-20

SWI Specifications Brochure for Steel Windows 8-6

TCA Handbook for Ceramic Tile Installation 9-4

TIMA Economic Thickness Manual 15-1, 15-61

TM 5-1300 22, 1-20, 1-101, 13-64, 13-69

TM 5-809-10 1-20, 1-93

TM 5-809-10.1 1-20, 1-93

TM 5-810-7/AFM 88-12 1-20, 15-68

TM 5-814-1 1-20, 2-37

TM 5-814-2 1-20, 2-37

TM 5-815-2 1-20, 1-62

TM 5-818-1 1-20

TM 5-818-5 1-20, 2-19

TM 5-830-3 1-20, 1-103, 1-105

TM 11-486-5 1-20, 5-2

TSCA 7, 1-10, 1-48,

UBC Standard No. 17-6 1-33, 7-9

UBC Standard No. 47-18 1-33, 9-3

UBC 8, 25, 27, 1-33, 1-48, 1-55, 1-93, 1-95, 1-96, 2-21, 2-22, 3-4, 4-1, 4-2, 5-1, 5-3, 6-1, 7-6, 7-9-12, 8-2, 8-3, 9-3, 10-2, 12-2, 14-1

UCRL 15673 1-35, 13-37, 13-38, 13-42

UCRL 15714 1-35, 9-4

UCRL 15910 1-35, 1-92, 1-93, 1-98-100

UCRL 53526 1-36, 1-92, 1-98

UCRL 53582 1-36, 1-93, 1-99

UFAS 8, 1-13, 1-48, 2-26, 2-27, 2-54, 10-5, 14-1-3

UL 10A 1-48, 1-87

UL 1479 1-49, 16-2

UL 155 1-48, 1-87

UL 207 1-48, 15-32

Double-hyphen entries indicate inclusive pages, e.g., “3-27-29” means page 3-27 through page 3-29. Entries for singular words can include plurals.

UL 325 1-48, 12-2

UL 365 1-48, 1-79

UL 493 1-48, 16-3

UL 508 1-48, 16-13

UL 586 1-48, 15-39

UL 723 1-48, 15-1, 15-68

UL 752 1-48, 2-61, 2-62, 13-26

UL 768 1-48, 8-7

UL 779 1-49, 9-6

UL 900 1-49, 15-39

UL 984 1-49, 16-12

UL 992 1-49, 9-6

UL Building Materials Directory 1-49, 16-2

UL Class A 1-79, 7-8

UL Class AA 1-79, 16-26

UL Fire Resistance Directory 1-49

UL listed 1-72, 7-9, 8-1, 8-3, 10-2-4, 12-3, 15-5, 15-17, 16-1

UPC 8, 1-33, 1-49, 2-45

Van Cott and Kincade 1-27, 1-49, 13-41, 13-42

Winterkorn and Fang, Foundation Engineering Handbook 2-20

WPCF MOP/8 CTG-77 2-45

WQA 1-10, 1-49, 2-39

WRC Bulletin No. 17A 2-66

☆ U.S. GOVERNMENT PRINTING OFFICE 1989—2 3 8 - 2 2 2 0 0 3 9 8

Double-hyphen entries indicate inclusive pages, e.g., "3-27-29" means page 3-27 through page 3-29. Entries for singular words can include plurals.

General Design Criteria (GDC) Improvement Proposal

U.S. DEPARTMENT OF ENERGY

Instructions: In a continuing effort to maintain the GDC as up-to-date as possible, DOE provides this form for use in submitting comments and suggestions for improvements. All GDC users, including DOE personnel, operating contractors, and private architects engineers are invited to provide suggestions. Be as specific as possible about perceived problem areas — wording that requires interpretation, is too restrictive, too loose, or ambiguous or criteria that warrant technical improvement — and give proposed wording changes that would alleviate the problem. Use a separate form for each recommended change and submit to your local GDC Planning Board representative. Where appropriate, attach marked-up copies of GDC pages. Recommended changes not following these guidelines cannot be acknowledged.

Note: This form cannot be used to request copies of the GDC or to request waivers, deviations, or clarification of specific requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the GDC or to amend contractual requirements.

Name: Delano Surdahl
Organization: FPMD
FTS#: 844-2070
Commercial Work Phone #: (505) 844-2070

Mailing Address: U. S. Department of Energy
P. O. Box 5400
Albuquerque, NM 87115

GDC Division #: 1 Section #: 0111-2.4.2 Title: Buildings and Other Structures

Type of Change — Circle One

Grammatical Minor Rewording Deletion Technical Addition* Major Rewording*

*These changes require an expanded discussion. Attach additional sheets as necessary.

EXAMPLE

Present Wording: None

Suggested Rewording: Add the following to the end of the paragraph "The procedures of TM 5-809-10 for the application of lateral seismic loadings to buildings shall also apply to the lateral wind forces."

Basis for Recommended Change: The lateral forces due to wind are similar to the lateral forces of seismic. There is no current guidance in how the wind forces are to be analyzed in the GDCM. The TM 5-809-10 has been used successfully by AL for several years as the basic guidance.

(Signature)
GDC Planning Board Representative

EXAMPLE

(Fold along this line)

UNITED STATES DEPARTMENT OF ENERGY
WASHINGTON, DC 20585

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE $300

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO 11301 WASHINGTON DC

POSTAGE WILL BE PAID BY ADDRESSEE

U.S. Department of Energy
Chairman, GDC Planning Board, MA-222
1000 Independence Ave., SW
Washington, DC 20277-1301

ERRATA SHEET

DOE 6430.1A, GENERAL DESIGN CRITERIA, of 4-6-89, was published with an incorrect reference on page 13-5. Please replace pages. 13-5 and 13-6 with the attached pages.

1300-3.3 Single Failure Criterion and Redundancy

The design shall ensure that a single failure (see Glossary) does not result in the loss of capability of a safety class system to accomplish its required safety functions. To protect against single failures, the design shall include appropriate redundancy and shall consider diversity to minimize the possibility of concurrent common-mode failures of redundant items.

1300-3.4 Equipment Environment Considerations

1300-3.4.1 General

Safety class items shall be designed to withstand the effects of, and be compatible with, the environmental conditions associated with operation, maintenance, shutdown, testing, and accidents. The environmental capability of equipment shall be demonstrated by appropriate testing, analysis, and operating experience, or other methods that can be supported by auditable documentation, or a combination of these methods.

1300-3.4.2 Environmental Qualification of Equipment

Equipment qualification shall provide assurance that safety class items will be capable of performing required safety functions under DBA conditions. The qualification shall demonstrate that the equipment can at least perform for the period of time that its safety functions are required. Subsequent equipment failure, after its safety function is no longer required, may be allowable.

Temperature, pressure, and humidity environments shall be based on the most severe postulated accident affecting the particular item. The postulated environment shall reflect an environment that considers both radiological composition (e.g., elements, isotopics, total radioactivity) and chemical composition (e.g., abrasives, acids, smoke, caustic vapors) of all material physical forms likely to affect the equipment.

1300-3.4.3 Equipment Operability Qualification

Testing or a combination of testing and analysis shall be the preferred method of demonstrating the operability of fluid system components, mechanical equipment, instrumentation, and electrical equipment that are required to operate during and following a DBE. Seismic experience data may be used as an alternative to testing or dynamic analysis where such data have been documented and validated. See Section 0111-99.0, Nonreactor Nuclear Facilities--General.

1300-3.5 Maintenance

The design shall consider the maintainability factors peculiar to the specific equipment to be used in the facility. Facility design shall provide for routine maintenance, repair, or replacement of equipment subject to failure.

Safety class items shall be designed to allow inspection, maintenance, and testing to ensure their continued functioning, readiness for operation, and accuracy. Ancillary equipment, such