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ORDER

DOE 6430.1

12-12-83

UNITED STATES DEPARTMENT OF ENERGY

GENERAL DESIGN CRITERIA MANUAL

U.S. Department of Energy
Washington, D.C.

ORDER

DOE 6430.1

12-12-83

SUBJECT: GENERAL DESIGN CRITERIA

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1. PURPOSE. To provide general design criteria for use in the acquisition of the Department's facilities and to establish responsibilities and authorities for the development and maintenance of these criteria.

2. SCOPE. The provisions of this Order apply to all Departmental Elements and contractors performing work for the Department as provided by law and/or contract and as implemented by the appropriate contracting officer.

3. APPLICABILITY.

   a. The design criteria provided by this Order shall be applied to all facilities at DOE-owned, -leased, or -controlled sites where Federal funds are used totally or in part, except where otherwise authorized by separate statute or where specific exemptions are granted by the Secretary or his designee.

   b. The general design criteria are not intended to provide complete coverage for the diverse facilities by type and complexity that are needed to support the varied Departmental program-mission requirements. Project specific criteria, or specifications, need to be developed to satisfy the needs for a particular facility incorporating applicable requirements in these general design criteria and supplemented with required criteria from applicable codes and standards.

   c. It is recognized that many of the Departmental organizations having responsibilities for facility planning, design, and construction may establish and apply more comprehensive criteria to satisfy the particular program mission or operating requirements. There is no intent that the general design criteria take precedence over such other criteria, where those criteria meet or exceed the general design criteria requirements.

4. REFERENCES.

   a. DOE 5700.4, PROJECT MANAGEMENT SYSTEM, of 1-8-81, which delineates the requirements, procedures, authorities, and responsibilities for the formal project management of DOE major system acquisitions and major projects.

   b. DOE 6410.1, MANAGEMENT OF CONSTRUCTION PROJECTS, of 5-26-83, which establishes policy and procedures to be followed in the planning, design, and construction of the Department's facilities.

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INITIATED BY:
Office of Project and
Facilities Management

c. Federal law and Executive order requirements for energy conservation and use of renewable energy sources in new Federal buildings, and implementing Federal regulation requirements, are identified in Chapter XIII of the general design criteria.

d. Other applicable Federal laws, Executive orders, and Federal regulations, are identified in the various chapters of the general design criteria where their requirements specifically apply.

e. Other Departmental Orders applicable to the planning and design, or acquisition, of Departmental facilities are contained in a general listing in Chapter I, Attachment I-1, and further identified in other chapters of the general design criteria where their requirements specifically apply.

5. DEFINITIONS.

a. Building Acquisitions by Lease or Purchase include new pre-engineered metal buildings, other semipermanent or temporary facilities such as inplant-fabricated modular/relocatable buildings and trailer units, and other buildings to be acquired.

b. Construction Projects include new facility, facility addition, and facility alteration projects where engineering and design are required in their performance.

c. Construction Project Planning includes all activities that are performed, after the initial identification of a project, for the purposes of developing the project concept, reliable cost estimates, realistic performance schedules, and methods of performance.

d. Facilities includes buildings and other structures, their functional systems and equipment, and other fixed systems and equipment installed therein; outside plant, including site development features such as landscaping, roads, walks, and parking areas; outside lighting and communications systems; central utility plants; utilities supply and distribution systems; and other physical plant features. As used in this Order, the term "nuclear facilities" is synonymous with the definition of this same term as contained in Chapter V, "Safety of Nuclear Facilities," of DOE 5480.1A, ENVIRONMENTAL PROTECTION, SAFETY, AND HEALTH PROTECTION PROGRAM FOR DOE OPERATIONS, of 8-13-81.

e. Project Design Criteria are those technical data and other project information developed during the project identification, conceptual design and/or preliminary design phases. They define the project scope, construction features and requirements, design parameters, applicable design codes, standards, and regulations; applicable health, safety, fire protection, safeguards, security, energy conservation, and quality assurance requirements; and other requirements. The project design criteria are normally consolidated into a document which provides the technical base for any further design performed after the criteria are developed.

6. POLICY AND OBJECTIVES.

a. Policy. It is DOE policy that:

(1) Professional architectural and engineering principles and practices be applied to the planning, design, construction, alterations, and/or acquisition of the Department's facilities.

(2) All Department facilities will comply with the Federal and Departmental regulations for energy conservation and use of renewable energy.

(3) All applicable laws, regulations, and Executive orders whether Federal, State, or local, will be satisfied in the planning, design, and construction of the Department's facilities.

(4) All Department facilities are designed and constructed to be reasonable and adequate for their intended purpose and consistent with health, safety, and environmental protection requirements.

b. Objectives.

(1) To provide general design criteria that ensures implementation of the Department's policy covering:

(a) The basic architectural and engineering disciplines.

(b) Certain types of the Department's known facility requirements.

(c) Specialized requirements based on programmatic and operating experience.

(2) To establish authorities, responsibilities, and procedures that ensure timely development and maintenance of the general design criteria.

(3) To establish responsibility for application of the general design criteria.

7. RESPONSIBILITIES AND AUTHORITIES.

a. Assistant Secretary, Management and Administration (MA-1), is responsible for the development of budget, accounting, procurement, cost estimating, construction, facilities management, site development, real estate, project management, and business related policy. Specific responsibilities with respect to general design criteria are carried out by the Director of Administration through the Director of Project and Facilities Management.

(1) Serves as the Department's focal point for the development, maintenance, and interpretation of the general design criteria. In fulfilling these responsibilities, technical advice and assistance is utilized from other Departmental organizations in their particular areas of interest.

(2) Maintains liaison with other Federal agencies, the architect-engineer professions, and the construction industries on current practices, procedures, criteria, and standards being applied to facility design and construction.

(3) Utilizes, as needed, technical advice and assistance of criteria users, support contractors, and consultants to develop and maintain criteria for specialized areas.

(4) Participates with the Advisory Board on the Built Environment, a unit of the National Research Council, in activities relating to facility design and construction.

(5) When requested, provides technical advice and assistance to other Departmental organizations on matters relating to planning, design, and construction of facilities.

(6) Assures that proposed criteria revisions and additions of a substantive nature are coordinated with all appropriate Headquarters and field organizations.

(7) Participates with responsible Headquarters organizations identified in paragraph c, below, in reviewing and adopting comments received on their particular areas of responsibility.

b. <u>Heads of Headquarters and Field Organizations Having Responsibilities for Construction Project Planning and Design or Facility Acquisitions</u>.

(1) Assure that the general design criteria are applied in construction project planning and design, including their application in development of the specific "project design criteria" and in development of technical specifications for facilities.

(2) Recommend criteria revisions and additions to the Director of Project and Facilities Management; and provide technical input, advice, and assistance during revision or expansion of the criteria.

c. <u>Heads of Headquarters Organizations Having Responsibilities for Establishing Policies, Performance Standards, or Operating Requirements That Need To Be Applied to the Planning, Design, Construction, or Acquisition of Department Facilities.</u>

(1) Participate in the development and maintenance of the general design criteria, and assure that the criteria accurately reflect the design requirements associated with their particular areas of responsibility.

(2) Assist the Director of Project and Facilities Management in reviewing and adopting comments and recommendations received from other Departmental Elements and DOE contractors, as related to their particular areas of responsibility.

(3) Identify and develop revisions or additions to the criteria in their particular areas of responsibility in coordination with the Director of Project and Facilities Management.

(4) Provide assistance to the Director of Project and Facilities Management and other Headquarters organizations, and field organizations, in making determinations of criteria applicability to specific facilities, and provide criteria interpretations, in their particular areas of responsibility.

8. <u>PROCEDURES AND REQUIREMENTS.</u>

a. Chapters I through XV of this Order contain basic criteria to be applied in the planning and design of facilities, and in the development of technical specifications for building acquisitions. Additional criteria to be applied for specific types of facilities are contained in other chapters, beginning with Chapter XVI.

b. It is recognized that there will arise valid reasons for deviating from the general design criteria. Allowable deviations are described in paragraph 2c, in Chapter I of the criteria. Criteria deviations requiring prior DOE Headquarters' review or approval, and procedures to be followed, are described in paragraph 2d of Chapter I.

c. Assistance from Departmental organizations having responsibilities assigned in paragraph 7 above and operating contractors will be required on a continuous basis for the effective maintenance of these general design criteria. A number of reserved chapters have been identified that reflect recommendations made by Headquarters and field organizations for expansion in criteria coverage. Development of these additional criteria chapters will be accomplished by working groups with participation by knowledgeable Headquarters, field organization, and operating contractor personnel and/or by use of support services contractors.

d. Past experiences (lessons learned) can be of significant benefit in the planning and performance of construction projects. Incorporation of design related "lessons learned" into the general design criteria will maximize the Department's benefits. Field organizations are encouraged to submit design related "lessons learned" to the Director of Project and Facilities Management.

BY ORDER OF THE SECRETARY OF ENERGY:

WILLIAM S. HEFFELFINGER
Director of Administration

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CHAPTER I

CRITERIA PURPOSE AND APPLICATION, AND FUNDAMENTAL DESIGN REQUIREMENTS

1. CRITERIA PURPOSE. Provide general technical direction and guidance to be applied in the planning and design of new facilities, in development of specifications for building acquisitions, and in the planning and design of facility additions and alterations, to assure that:

   a. Professional architectural and engineering principles and practices will be followed.

   b. Health and safety requirements of DOE employees, the public, and DOE contractor or subcontractor employees using DOE facilities are satisfied.

   c. Fire protection, environmental protection, quality assurance, safeguards and security, and other basic requirements will be satisfied, together with the satisfaction of program needs.

   d. New facilities, facility additions, and facility alterations will be planned and designed to achieve economies in construction, operation, and maintenance.

   e. New buildings, building additions, and other energy-using facilities, and additions or alterations thereto, will incorporate energy conserving features on the basis of their life cycle cost effectiveness; will be consistent with the Department's fuels and energy use policy in the use of nonrenewable energy resources; and will use renewable energy whenever these applications are technically feasible and life cycle cost effective.

   f. Requirements of applicable Federal laws, Executive orders, Federal regulations, applicable local, regional or State regulations, applicable national consensus codes and standards, and other DOE-prescribed standards and requirements will be satisfied.

2. CRITERIA APPLICATION.

   a. Definition of Terms.

      (1) Shall - denotes a requirement.

      (2) Should - denotes a recommendation.

   b. Use of the Criteria.

      (1) These general design criteria shall be applied in the planning and design of new DOE facilities, facility additions, and facility alterations. This includes application in the preparation of the specific project design criteria during the project planning phase.

(2) These criteria shall be applied in the acquisition of new pre-engineered metal buildings and in-plant fabricated modular/relocatable buildings, and in the acquisition of other buildings and other semipermanent or temporary facilities including trailer units, to the extent technically, economically, legally, or contractually feasible.

(3) Paragraph 3 in this Chapter I contains fundamental design requirements. Chapters II through XV contain the more discipline-oriented design criteria. Follow-on chapters, beginning with Chapter XVI, contain additional criteria for certain types of facilities either common to most DOE sites and operating requirements, or of a specialized nature. In their application, these general design criteria should be used as a whole because of the interrelationships or interdependence among the various chapters.

(4) The general design criteria incorporate, either directly or by cross-reference to other DOE directives, applicable requirements and guidance promulgated by those Headquarters organizations having assigned responsibilities in such areas as health protection, safety, fire protection, environmental protection, safeguards and security, quality assurance, telecommunications, energy management, site selection, site development planning, and other areas.

(a) Collective use needs to be made of the general design criteria and other DOE directives listed in Attachment I-1, and as individually identified in the various chapters of this Order. Contractors or subcontractors providing facility planning or design services, or building acquisition services, to the Department will need to be apprised of all applicable requirements and guidelines.

(b) Where there are conflicts between the general design criteria and any of the referenced DOE directives they should be brought to the attention of the Headquarters Office of Project and Facilities Management for mutual resolution with other responsible Headquarters organizations. Continuing efforts will be made to assure that the general design criteria and the referenced DOE directives provide consistent technical direction and guidance.

(5) Departmental organizations having first-line responsibilities for facility planning, design, and construction have the authority to determine to what degree the criteria in this Order are to be applied to facility planning or design work which was started prior to issuance of this Order. In making these determinations, attention needs to be given to the current stage of facility planning or design; potential cost and schedular impact of applying the criteria; any applicable requirements of Federal laws, regulations, Executive Orders, or other DOE directives identified within the criteria; and other appropriate factors.

(6) These general design criteria are, in substantial part, a update of the general design criteria that were used by many of the field organizations in the prior U.S. Energy Research and Development Administration, and in the U.S. Atomic Energy Commission prior to January 1975. In its current form, this Order reflects the numerous technical comments, suggestions, and recommendations submitted by DOE field and Headquarters organizations from their review of the draft that was transmitted for DOE-wide coordination in June 1981. Many recommendations were also received for significant expansion of some of the criteria coverage in the architectural and engineering discipline-oriented chapters, and to include new criteria for other types of facilities and systems. These additional design criteria have not been included in the current Order. Subsequent development, and circulation of draft criteria for appropriate review, comment, and concurrence, will be needed for such substantive criteria additions.

c. Allowable Deviations.

(1) These general design criteria are not intended to impose unnecessary design restrictions or discourage design innovation. Professional architectural and engineering judgment needs to be used in their interpretation and application to the specific project. Departmental organizations having first-line responsibilities for facility planning and design, or building acquisitions, are afforded the latitude to deviate from the criteria and to grant deviations to DOE operating contractors or other contractors performing such services for the Department when, in their judgment:

(a) A specific portion of the general design criteria is determined to be inadequate or inappropriate for certain components of production, manufacturing, research and development, or other similar types of facilities.

(b) Minor deviations are necessary or advantageous.

(c) A specific portion of the general design criteria does not reflect currently applicable codes, standards, guides, regulations, or architectural or engineering principles and practices.

(d) Deviations will achieve greater economies in facility construction, operation, or maintenance without adverse impact on satisfaction of programmatic or operating needs; and on satisfaction of applicable health, safety, fire protection, safeguards, security, environmental protection, and quality assurance requirements, or other essential requirements.

(e) Deviations are determined to be necessary in the acquisition of buildings by lease or purchase.

(f) Deviations are determined to be necessary and are allowable under existing exemption or variance provisions of another DOE directive referenced in this Order.

(2) When deviations are taken because of deficiencies in the general design criteria, such criteria deficiencies should be brought to the attention of the Office of Project and Facilities Management for possible corrective action. If conflicts arise because other DOE directives allow deviations of this Order, not allowed herein, they should also be brought to the attention of the Office of Project and Facilities Management (see paragraph 2b(4)(b), above).

d. Criteria Deviations Requiring Prior DOE Headquarters' Review or Approval.

(1) In the planning and design of the following types of facilities, deviations from the general design criteria will require prior review or approval at the Headquarters level.

(a) Plutonium Processing/Handling Facilities (Chapter XXI).

(b) High Explosives Facilities (Chapter XXII).

(c) Unirradiated Enriched Uranium Storage Facilities (Chapter XXIII).

(2) Deviations from requirements in applicable Federal laws, Federal regulations, Executive orders, or local, regional or State codes or regulations will generally require prior review or approval at the Headquarters level. See paragraph 3a(5), below, with regard to application of State, regional or local codes or regulations.

(3) Deviations from other portions of the general design criteria, other than as discussed in paragraphs (1) and (2), above, can also necessitate prior review or approval at Headquarters when, in the judgment of the Departmental organization having first-line responsibility for facility planning, design, construction, and operation, such deviations will or may have significant adverse impact in the areas of health, safety, environmental protection, or other essential areas.

(4) Deviations, described in paragraphs (1) through (3) above, should be identified early in the planning phase and discussed with appropriate Headquarters elements. Mutual determinations can then be made as to the need for formal submittal of the proposed deviation to Headquarters for additional review or approval. This is of particular importance for construction projects, where decisions could have a significant impact on project scope and cost, and where early decisions are needed to avoid delay in completing the planning work or start of design.

(5) In those cases where Headquarters' approval of deviations is determined to be necessary, the field organization shall prepare and submit a request, with justification, for appropriate action.

(a) Requests for exemption or variance from codes, standards, or regulations prescribed in the general design criteria that are also identified as "prescribed standards" in Chapter I of DOE 5480.1A, ENVIRONMENTAL PROTECTION, SAFETY, AND HEALTH PROTECTION PROGRAM FOR DOE OPERATIONS, shall be made in accordance with the requirements in paragraph 4, "Procedures for Granting Exemptions," in Chapter I of DOE 5480.1A. Where other chapters of DOE 5480.1A or other DOE directives referenced in this Order contain specific requirements for requesting Headquarters approval of exemptions or variances from their provisions, the requirements in those directives shall also be followed.

(b) Other requests for approval of criteria deviations in the areas of health, safety, or environmental protection shall be submitted to the appropriate Headquarters outlay program organization, with copies to: the appropriate organizational element under the Assistant Secretary, Environmental Protection, Safety, and Emergency Preparedness; the Office of Project and Facilities Management; and to other appropriate Headquarters organizations. Note that Departmental line organizations (includes Headquarters outlay program and field organizations) have been assigned responsibilities for health, safety, and environmental protection in the conduct of DOE programs; and construction projects or building acquisitions are elements of these programs. For reference, see DOE 5480.1A of 8-13-81, and DOE 3790.1 of 12-11-80.

(c) Requests for approval of criteria deviations in areas other than health, safety, or environmental protection shall be submitted to the Office of Project and Facilities Management, with copies to the appropriate Headquarters outlay program organization and to other responsible Headquarters organizations. Approval action will be taken by the Office of Project and Facilities Management, or action may be taken by the appropriate outlay program organization or by other responsible Headquarters organizations, as mutually determined.

(6) Criteria deviation approval actions shall be coordinated with all responsible Headquarters organizations. Whenever possible, these actions should be performed at no higher than the office or division director level to expedite the process.

(a) Deviations from requirements in applicable Federal laws, Federal regulations, or Executive orders, or applicable local, regional or State codes or regulations will generally require higher levels of approval at Headquarters. As needed, advice and guidance shall be obtained from the Office of General Counsel to interpret and determine the applicability of the requirements to the specific facility.

(b) Interim responses shall be provided by the responsible Headquarters organization when approval actions will require more than 30 calendar days to complete.

3. FUNDAMENTAL DESIGN REQUIREMENTS. The following criteria contain fundamental design requirements that are to be applied together with the other more specific criteria contained in the other chapters.

a. Codes, Standards, Guides, and DOE Directives.

(1) The latest editions of codes, standards, guides, and other DOE directives identified in this and other chapters of these general design criteria shall be followed in the planning and design of DOE facilities. Referenced codes and standards, and other DOE directives are normally mandatory, unless otherwise indicated.

(2) In general, the basic building code to be used shall be whichever nationally recognized code is used in the State where the project is located (e.g., Uniform Building Code, Standard Building Code). Project requirements and referenced codes and standards within these criteria shall take precedence for specific design conditions. At a minimum, the "Uniform Building Code," issued by the International Conference of Building Officials (ICBO), shall be used in the determination of earthquake loads for buildings and other structures (except where more stringent requirements are imposed in applicable building codes of the State where the project is located). The application of dynamic analysis techniques (as covered in the Earthquake Regulations Section 2312(i), of the Uniform Building Code, 1979 edition) may be required for certain types of buildings and structures. See paragraph 9c (Earthquake Loads) in Chapter IV, "Architectural and Structural," for additional criteria.

(3) In general, the basic codes to be followed for fire protection are the National Fire Codes of the National Fire Protection Association (NFPA). The basic codes to be followed for electrical system design are the National Electrical Code, American National Standards Institute (ANSI)/NFPA-70, and the National Electrical Safety Code, ANSI C-2. The basic codes, standards and guides to be followed in mechanical system design are the National Plumbing Code and American Society of Heating, Refrigerating, and Air-Conditioning Engineers,

Inc. (ASHRAE) Handbooks and standards. These and other codes, standards, and guides to be followed are identified in the various chapters of this order.

(4) Use of Federal Specifications and Federal Standards, and development of purchase descriptions (specifications), shall be in accordance with the General Policies in Subpart 9-1.3 of the DOE Procurement Regulations, DOE/PR-0028 of 6-79.

(5) Local, regional, or State codes or regulations shall be followed to comply with water quality and air pollutant emission standards established by the Federal Water Pollution Control Act and Clean Air Act, respectively. Compliance with regulations and standards concerning solid waste disposal, disposal of oils, and disposal of hazardous materials shall also be assured. Other local, regional, or State codes, regulations, or standards for environmental protection, safety, or health protection that are determined to be applicable to DOE operations, and are more stringent than those identified in these general design criteria, shall also be followed. In all cases, DOE standards and requirements for radiation protection apply for radioactive effluents.

(6) Paragraph 7c(8) of DOE 5480.1A, ENVIRONMENTAL PROTECTION, SAFETY, AND HEALTH PROTECTION PROGRAM FOR DOE OPERATIONS, of 8-13-81, requires that Heads of Field Organizations establish and maintain appropriate liaison with local, regional, or State officials; and advise responsible program Secretarial Officers and the Assistant Secretary, Environmental Protection, Safety, and Emergency Preparedness of environmental protection, safety, and health protection requirements issued by these officials that will affect their operations.

(7) Compliance with applicable local (or utility company) codes, regulations, or standards will also be required for tie-in to local utility services (e.g., water, electric, gas, or sewer). Local codes and standards shall be complied with for fire equipment and connections when local fire department support is needed.

(8) Where local, regional, or State codes or regulations are not applicable, and where DOE directives are not existing or applicable, DOE field organizations shall adapt their own design standards or guides to assure that proper health and safety of personnel and protection of property will be achieved.

(9) New DOE facilities, and additions or alterations to existing facilities, shall be so planned and designed to assure that health and safety provisions are consistent with the occupational safety and health standards issued by the Department of Labor (DOL) under Section 6 of Public Law 91-596 (Occupational Safety and Health Act of 1970), as amended, or with more stringent standards.

(10) In the event of a conflict between this Order and a referenced code or standard herein, the more stringent requirements shall be followed.

(11) Copies of the building codes and other codes, standards, and guides referenced in the various chapters of this Order may be obtained from the reference sources shown in Attachment I-2. Copies of referenced DOE directives, listed in Attachment I-1, may be obtained from Headquarters or field organizations, as appropriate.

b. Health, Safety, and Fire Protection.

(1) Advice and guidance shall be utilized from cognizant DOE, and DOE contractor, health, safety, and fire protection personnel during the project planning and design process. This is to assure that all health, safety, and fire protection requirements are adequately identified and the necessary features are incorporated. Analyses of hazards and assessment of risks shall be made during conceptual design and preliminary (Title I) design, and further developed during the detailed (Title II) design phase. These analyses shall include identifying the measures to be taken to mitigate the hazards and achieve accepted levels of risk. In most cases, these analyses are included in the project planning and design documentation (e.g., in conceptual design reports, Title I design reports). For DOE nuclear facilities or other facilities having high levels of hazard, the preliminary safety analysis report (PSAR) shall be prepared during conceptual or preliminary design and the draft safety analysis report (SAR) completed during Title II design, or prior to facility operation at the latest. Safety analyses shall be in accordance with the requirements in DOE 5481.1A, SAFETY ANALYSIS AND REVIEW SYSTEM, of 8-13-81, and safety analyses and Safety Analysis Reports shall be made a part of the project records.

(2) The extent of the safety analysis required will be commensurate with the nature of facility operations and associated health and safety hazards. Areas to be addressed in safety analysis (and safety analysis reports) include, but are not necessarily limited to those listed below:

(a) Form, type, and amount of hazardous materials (nuclear or other) to be stored, handled, or processed.

(b) Principal hazards and risks which may be encountered in facility operation, during the projected facility life, including potential injury and property damage accidents due to fire, explosion, radiation, toxic exposure, structural failure, wind, flood, earthquake, tornado, operating error, failure of essential operating equipment, failure of safety systems, and so forth. Predicted consequences of such accidents to employees and the public are included.

(c) Selected design bases, such as design basis fire (DBF), design basis earthquake (DBE), design basis tornado (DBT), operating basis accidents (OBA), design basis flood (DBFL), and so forth, postulated and quantified, including rationale for selection.

(d) Principal design, construction, and operating features selected for preventing accidents or reducing risks to acceptable levels, including safety margins employed, to demonstrate that the facility and its operation will meet health and safety objectives.

(e) See DOE 5481.1A for safety analysis requirements that may not have been covered herein.

(3) Performance objectives to be achieved in the design of DOE facilities for protection against fire, explosion, and other hazards include:

(a) Protection of the public against injury and protection of private property against damage resulting from DOE operations.

(b) Protection of DOE and DOE contractor employees from accidental injury, and from exposure to toxic materials and radiation in accordance with DOE standards and allowable limits.

(c) Provision for continuity in operations by minimizing accident potential.

(d) Limitation of loss or damage potential to Federal Government property, including loss that may be incurred by being unable, or difficult to decontaminate/decommission facilities for other beneficial uses at the end of their useful life.

(4) General design criteria for fire protection are contained in Chapter X of this Order.

c. <u>Safeguards and Security</u>.

(1) Advice and guidance from cognizant DOE and DOE contractor safeguards and security personnel shall be utilized during the project planning and design processes to assure that requirements are properly identified and the necessary features are incorporated. Facilities shall be designed to satisfy DOE safeguards and security standards and requirements, as promulgated by the Headquarters Office of Safeguards and Security, and as individually referenced within this Order.

(2) The types and number of features required for safeguards and security purposes will depend upon such factors as the facility location, if the facility (or portion thereof) has a classified interest, if the facility (or portion thereof) houses significant quantities of classified material and information, the relative sensitivity of the work to be performed, and the value of the resources housed.

Consideration shall be given to the feasibility of consolidating security interests within a security area, consistent with the need to compartmentalize information, materials, and activities.

d. Environmental Protection and Pollution Control.

(1) Advice and guidance from cognizant DOE and DOE contractor environmental protection and pollution control personnel shall be utilized during the project planning and design processes to assure that requirements are properly identified and the necessary features are incorporated, and to provide adequate time to obtain any permits which may be required.

(2) Requirements for prevention, control, and abatement of potential forms of environmental pollution shall be determined in the project planning phase. Necessary features shall be incorporated into the project design to satisfy DOE environmental protection and pollution control requirements as promulgated by the Headquarters' Office of Environmental Compliance and Overview and as individually referenced within these criteria. General design criteria for air and water pollution control are contained in Chapter XI and Chapter XII, respectively.

(3) Requirements and procedures to be followed in the implementation within the DOE of 10 CFR Part 1021, "Compliance With the National Environmental Policy Act," are contained in DOE 5440.1B, IMPLEMENTATION OF THE NATIONAL ENVIRONMENTAL POLICY ACT, of 5-14-82. The "Environmental Compliance Guide," Volumes I and II, available from the NEPA Affairs Division, Office of Environmental Compliance and Overview, at DOE-Headquarters, provides detailed guidance to assist Departmental organizations in implementation of and compliance with the National Environmental Policy Act of 1969, as amended, and with other Federal environmental requirements that may apply to DOE projects. These other requirements include, but are not limited to, the Clean Air Act, the Clean Water Act, the Coastal Zone Management Act, the Endangered Species Act, the Fish and Wildlife Coordination Act, the Wild and Scenic Rivers Act, the Historic Preservation Act, the Non-Nuclear Research and Development Act (Water Resource Evaluation), the Resource Conservation and Recovery Act, the Safe Drinking Water Act, and the Toxic Substance Control Act; and implementing Federal regulations.

e. Telecommunications, Energy Management, and other Facility-Related Requirements. Advice and guidance shall also be utilized from other DOE and DOE contractor personnel during project planning and design to assure that other requirements are also properly identified and necessary features incorporated. Satisfaction of requirements promulgated by the DOE Headquarters' Office of Computer Services and Telecommunications Management, the In-House Energy Management Branch (in the Office of Project and Facilities Management), and by other DOE-Headquarters organizations within their areas of responsibility is required.

f. Quality Assurance.

(1) Facility design shall incorporate the necessary quality assurance (QA) requirements to assure that established program/project quality objectives are being satisfied.

(2) Quality assurance encompasses all those planned and systematic actions and controls necessary to provide adequate confidence that a structure, system, or component will perform satisfactorily in service. Quality assurance includes quality control, which comprises those quality assurance actions related to the physical characteristics of a material, structure, component, or system which provide a means to control the quality of the material, structure, component, or system to predetermined requirements.

(3) An adequate quality assurance program provides assurance that the design will satisfy program/project requirements; the prepared drawings and construction specifications adequately incorporate quality assurance requirements; construction can be performed in accordance with design; and tests confirm the adequacy of design and quality of construction and manufactured components, where appropriate.

(4) As a part of the quality assurance program, architectural and engineering portions of design need to be closely coordinated during the conceptual, preliminary (Title I), and detailed (Title II) design phases to avoid conflicts that could result in costly changes during construction. Prior to initiating Title I and Title II design, quality assurance requirements need to be established for the project, systems, subsystems, and components. It must be determined what the facility is to accomplish; the range of operating conditions; the required degree of reliability; its intended useful life; and how it can be maintained, repaired, or replaced.

(5) Wherever possible, design shall reflect experience gained on similar projects, or similar types of construction.

(6) Provisions need to be made for review and checking design calculations, drawings, and construction specifications by qualified personnel, other than those responsible for the original design. To the extent practicable, and particularly in the case of innovative design, the design should be reviewed by competent consultants in construction or manufacturing techniques to confirm the practicability of construction or manufacture.

(7) See DOE 5700.6A, QUALITY ASSURANCE, of 8-13-81, for additional information, direction, and guidance.

g. Facility Economies.

(1) It is a fundamental objective that all DOE facilities be planned and designed to satisfy program/project needs and operating requirements

at minimum cost. It is important that good professional architectural and engineering principles and practices are applied, including performance of adequate engineering and economic studies. For typical building projects, these studies should address those features which generally contribute most to the total project cost, such as:

(a) Siting, including site development.

(b) Architectural features, including building orientation, configuration, story heights, and envelope.

(c) Structural systems.

(d) Heating, ventilating, and air-conditioning systems.

(e) Electrical systems.

(f) Piping and sprinkler systems.

(2) In the evaluation and selection among energy-related building systems and features, and where feasible in the evaluation and selection among other design alternatives, life-cycle costing principles need to be applied. The purpose is to arrive at the most economical level of cost that takes into account not only the initial cost but also the operating and maintenance costs over the estimated life of the building (or building addition). For purposes of life cycle cost analysis for energy conservation and use of renewable energy sources, as covered in Chapter XIII, the estimated useful life to be used for DOE buildings shall not exceed 25 years (because of the uncertainties and inaccuracies in projecting operating and maintenance costs beyond that time). Where life cycle cost analysis applications may be feasible in the evaluation and selection among other design alternatives, the same maximum value should be applied.

(3) The architectural quality of construction should be no higher than that necessary to satisfy program or operating needs. For service and industrial-type facilities, an austere architectural treatment should be the objective. Higher qualities may be provided for facilities of more sophisticated use or occupancy. See Chapter IV (Architectural and Structural) for additional criteria.

(4) Design shall take into consideration the economies that can be achieved by the use of local materials, construction methods, and construction skills.

h. Energy Conservation and Use of Renewable Energy Sources. Chapter XIII contains the basic general design criteria for energy conservation and use of renewable energy sources to be applied in the planning and design or acquisition of the Department's energy-using facilities. Additional energy-conservation design criteria are contained in Chapter IV, Chapter V, Chapter VI and Chapter VIII of this Order.

i. Facility Siting.

(1) Procedures and requirements to be followed for new site selections are contained in DOE 4300.1A, REAL ESTATE MANAGEMENT, of 7-7-83. In locating new buildings and other structures on an existing or new site, the site development plan (see DOE 4320.1A, SITE DEVELOPMENT AND FACILITY UTILIZATION PLANNING, of 3-17-83) shall be followed, consistent with the need to assure effective site utilization, orderly and efficient future site development. In selecting the location, either during site development planning or later, careful attention shall be given to:

(a) Programmatic and operating efficiency;

(b) Special siting requirements for facilities containing, using, or processing hazardous materials;

(c) Hazardous operations and consequences of potential accidents in adjacent facilities;

(d) Site seismicity;

(e) Security and safeguards requirements;

(f) Efficient use of existing or planned utility and support facilities, roads, and parking areas;

(g) Interrelationships between facilities and aesthetic compatability; and

(h) Energy conservation needs.

(2) The National Environmental Policy Act (42 U.S.C. 4321 et seq), of 1-1-70, the Department of Energy Guidelines for Compliance with the National Environmental Policy Act (45 FR 20694, as amended), of 3-28-80, and DOE 5440.1B, IMPLEMENTATION OF THE NATIONAL ENVIRONMENTAL POLICY ACT, of 5-14-82, require the preparation of an environmental assessment prior to the initiation of a Government action which may have a major impact on the environment. This requirement should be considered during facility siting.

(3) The minimum fire separation distance between buildings should be determined as prescribed in the NFPA 80A, "Recommended Practice for Protection of Buildings from Exterior Exposure Fires," except where more stringent requirements are imposed by applicable local codes or regulations, or when project-specific requirements dictate otherwise. See Chapter X for additional criteria.

(4) To the maximum extent practicable, facility siting shall preclude the use of floodplains and areas subject to flash flooding; and shall minimize destruction, loss, or degradation of wetlands. Requirements and procedures to be satisfied with regard to use of floodplains and protection of wetlands are contained in:

(a) Executive Order 11988, "Floodplains Management," of 5-24-77;

(b) Executive Order 11990, "Protection of Wetlands," of 5-24-77; and

(c) Implementing DOE regulations in 10 CFR Part 1022, "Compliance With Floodplains/Wetlands Review Requirements."

(5) Radiological siting requirements are being developed and will be placed in this section. In the interim, the Director of Nuclear Safety (EP-34) will provide siting guidance.

j. Site Development.

(1) Topography should strongly influence project design, and facilities should be planned to fit the topography with a minimum of grading, and to preserve the site character in an efficient and economical manner.

(2) Landscaping shall provide the creation and maintenance of an attractive setting commensurate with the location and type of facilities to be constructed. Plantings shall be simple, functional, and economical to maintain, and plant species proven to be locally hardy and tolerant of specific site conditions shall be selected. The species of trees, and their location in planting, shall be such as to preclude roots from damaging underground utility lines and adjacent surface facilities, wherever possible. Landscaping should be consciously used as an element in energy conservation design solutions for buildings. Proper landscaping benefits include reduction of solar radiation during cooling season, heat loss from wind and heat loss during heating season.

(3) Site grading design shall provide for adequate surface drainage, preservation of the natural character of the terrain by minimum disturbance of existing ground forms and vegetation, and minimum earth movement with a reasonable balance between cut and fill. Site grading design shall also take into account the need for safety and ease of personnel and vehicular access to the facility. This is of particular importance with regard to accessibility to facilities by physically handicapped persons.

(4) Sidewalks and walk gradients, shall be designed to provide for safe and convenient facility access and egress and inter-facility circulation. Widths of walks shall be based on anticipated traffic. Where steps are required, single risers should not be used, because they are not easily recognizable by pedestrians and can constitute a

significant safety hazard. However, all steps in walks, as well as steps in entrances or exits for buildings shall be avoided wherever possible. This is important for the safety and convenience of physically handicapped persons.

(5) The design of roads and associated drainage systems shall take into account soil, geologic, topographic, and climatic conditions. Studies shall be made to estimate the volume and character of traffic, both during the construction and operating phases. In planning and design, the timing of road construction (i.e., seasonality) needs to be given careful consideration. Controlled speed of vehicles within congested areas can permit the profile of roads to conform generally to the ground surface, thus allowing maximum utilization of adjacent areas and achieving economy in road construction costs. For long stretches of inter-area or interplant roads, speeds of 55 miles per hour shall generally be assumed for design purposes except where local conditions dictate lower speeds. Where future expansion is anticipated, sufficient right-of-way shall be reserved. Underground utilities shall be designed and construction planned to minimize interference with road construction.

(a) Wherever feasible, construction roads shall be established in locations and with profiles proposed for the final road system, and with shoulders and bases that can be surfaced after the construction period for use as the permanent roads.

(b) For environmental protection, the construction of road ditches and other work necessary to obtain adequate drainage and stabilization of soil for roads and construction areas shall be initiated and completed as early as possible in the project construction phase. In addition, roadways, ditches, and drainage structures need to be carefully maintained during construction. Construction road surfaces should be treated during dry periods to minimize air pollution. See Chapter XI (Air Pollution Control) and Chapter XII (Water Pollution Control) for additional criteria to be applied in planning for the control of pollution during construction activities.

(c) Safety is a primary requirement in road design. Designs shall, as applicable, conform with:

1 American Association of State Highway and Transportation Officials (AASHTO) publications;

a "A Policy on Geometric Design Standards for Highways Other than Freeways;"

b "Highway Design and Operational Practices Related to Highway Safety;"

c "Standard Specifications for Highway Materials and Methods of Sampling and Testing;"

d "Standard Specifications for Highway Bridges;"

e "A Policy on Arterial Highways in Urban Areas;"

f "A Policy on Geometric Design of Rural Highways;" and

g other AASHTO publications.

2 U.S. Department of Transportation "Handbook of Highway Safety Design and Operating Practices;"

3 ANSI Standard D6.1, "Manual on Uniform Traffic Control Devices for Streets and Highways;"

4 ANSI/IES RP8, "Practice for Roadway Lighting;" and

5 Recommendations in the Illuminating Engineering Society (IES) Lighting Handbook.

(6) For storm drainage, open drainage ditches protected against erosion should be used to the maximum extent practicable, and should be designed for not less than a 25-year frequency storm. One-hundred year frequency storms should be evaluated for consequences of damage to the drainage areas. Materials locally available should be utilized for culverts and pipe systems, where economical. Where required for safety or sanitary reasons, or where determined to be economical from a drainage system maintenance standpoint, short closed-piping systems may be extended from the open drainage systems to allow complete removal of the 25-year overland storm flow from the street system. Auxiliary structures or appurtenances such as headwalls, catch basins, manholes, and so forth, should be that minimum necessary to satisfy requirements. Corps of Engineers or other appropriate design manuals should be utilized for technical guidance in the areas of hydrology and open-channel design.

(7) Vehicle parking requirements shall be carefully determined, with proper consideration given in their planning and design to the following factors:

(a) Occupancy of the facility to be served.

(b) Provisions for physically handicapped persons.

(c) Employee commuting methods (obtained from survey data or estimates, including single drivers, carpools, vanpools, public transportation, percentages of standard and compact-sized vechicles, and so forth).

(d) Service vehicle and vistor parking needs.

(e) Single facility parking areas vs. joint-use parking for adjacent facilities.

(f) Aesthetics (siting, landscaping).

(g) Location of fire protection devices (hydrants, pumper connections) and accessibility for responding emergency apparatus.

(h) In planning parking lots, care shall be taken to avoid the extremes of numerous small parking lots or massive-sized parking lots. See 41 CFR Chapter 101, Subpart 101-20.117-2, for policies to be followed in assignment of parking spaces.

(8) Site and building signage shall be in accordance with U.S. Department of Energy "Graphic Design Standard 8," as contained in the "U.S. Department of Energy Design Guide," of 10-77 (or later revision).

k. Interior Building Services.

(1) Building service equipment shall be located as centrally as possible to shorten distribution lines and achieve economies of construction and operation. Pipe runs and other service lines should be planned to utilize common shafts, trenches, or raceways; be readily accessible for maintenance; and relate to the building structure in an orderly manner requiring a minimum of concealment. Electrical equipment shall be located in rooms or spaces dedicated exclusively to such equipment, in accordance with the National Electrical Code (ANSI/NFPA-70), Article 384.

(2) Critical or emergency services shall be physically separated or adequately protected from normal services, both in point(s) of origin and service runs to minimize the possibility of dual failures from single-contingency failure of the normal services.

(3) Valves, fixtures, and equipment shall be readily accessible for operation, inspection, and maintenance.

(4) An easily recognizable color and legend code shall be utilized for service distribution lines. The facility services' coding system shall be consistent throughout the plant or site complex, to the maximum extent feasible. ANSI Standard A13.1, "Scheme for the Identification of Piping Systems," is recommended for use for such systems. Differences between facilities (such as between the older facilities and new facilities), in color-coding could constitute a significant safety hazard to plantwide operating and maintenance personnel. Such differences should be identified by posting the color and legend code in operating and maintenance areas and including it in operating and maintenance manuals for facilities where differences from the adopted standard coding system exist. Another solution is to permanently attach to the distribution lines tags or signs with the proper identification stenciled or printed on them.

(5) Service equipment and distribution system characteristics (e.g., operating temperature, pressure, vacuum, voltage) and related safety warnings shall be clearly posted.

1. Outside Utility Services.

(1) Steam, hot water, or chilled water plants; water pumping stations and storage reservoirs; fuel yards and tanks; electrical substations; and other service facilities should be located as near as practicable to load centers, considering appearance and hazard factors, to minimize size and length of service lines and energy losses. Central utility plants shall be provided and used in lieu of individual building service equipment wherever economically advantageous, with proper consideration given to energy savings on a life cycle costing basis.

(2) Placement of mechanical (e.g., steam), electrical, and telecommunications service distribution lines aboveground shall be determined from evaluation of such factors as economies, reliability needs, safety, aesthetics, and need for conformance with local practices. In developed areas, except for industrial or storage facility areas, services should generally be placed underground. In the case of aboveground placement, design and construction techniques and materials should be appropriately utilized to provide a pleasing appearance. Architectural and structural features such as provided by the use of tapered metal power poles, attractive wood poles or structures, low-level electric or piping support structures, enclosures, landscaping, and screening should be considered. Measures may need to be taken to reduce adverse environmental impact for such facilities as overhead electrical lines. One recommended source of information and guidance is the "Environmental Criteria for Electric Transmission Systems," of 2-10-70, developed by the U.S. Departments of Interior and Agriculture.

(3) Underground services should be located, and their runs identified with aboveground markers at strategic locations when approporiate, so that minimum effort and cost will be incurred should maintenance, repair, or replacement be necessary. Accurate, and current, "as-built" drawings need to be maintained, identifying each underground service, location of manholes, splice boxes, placement depths, plan-view dimensioning of service runs and locations, and so forth. Common trenches should be used for multiple utility services where practicable, with adequate horizontal and vertical separation for operating reliability and safety. However, steam and condensate return lines and hot water lines shall be separated from chilled water lines, and all these lines shall be separated from other thermally-sensitive or moisture-sensitive services (e.g., electrical and communications services). To the extent practicable, underground utility lines should not be located under roads, parking, or other paved areas where excavation would be needed for repair or replacement. A recommended reference source on underground heat distribution systems is Federal Construction Council (FCC) Report No. 66, "Criteria for Underground Heat Distribution Systems." Cathodic protection of

underground piping, when required, should be installed simultaneously with the piping systems.

(4) Utilities and related service requirements for new buildings, or building additions, need to be identified in the project planning phase, and evaluated against existing service capabilities on the site and offsite. Where the site or facility services are provided or are to be provided under contractual service agreements with commercial utilities and service companies, it is important to advise these companies of projected requirements as early as practicable. This is particularly important when these requirements will necessitate expansion of their service capabilities, involve contract negotiations or will require that costs associated with the expansion to be borne by the Department. When expansion costs are to be borne by the Department, they shall be included in the project cost estimate.

(5) The design of outside utility services for the handling, storage, or distribution of hazardous gases shall be in accordance with applicable National Fire Protection Association (NFPA) "National Fire Codes," at a minimum. Advice and guidance from the DOE fire protection authority having jurisdiction shall be utilized. Applicable NFPA codes and standards include:

(a) NFPA 50, "Standard for Bulk Oxygen Systems at Consumer Sites."

(b) NFPA 50A, "Standard for Gaseous Hydrogen Systems at Consumer Sites."

(c) NFPA 50B, "Standard for Liquified Hydrogen Systems at Consumer Sites."

(d) NFPA 54 (ANSI Z223.1), "National Fuel Gas Code."

(e) NFPA 58, "Standard for the Storage and Handling of Liquified Petroleum Gases."

(f) NFPA 59A, "Standard for the Production, Storage and Handling of Liquified Natural Gas (LNG)."

m. Operating and Maintenance Provisions.

(1) General Considerations.

(a) Planning and design of buildings and other structures, including their operating components and systems, shall take into account all aspects of operation and maintenance including:

1 equipment accessibility;

2 dismantling;

3 replacement;

4 repair;

5 frequency of preventive maintenance;

6 inspection requirements;

7 personnel safety; and

8 day-to-day operation.

(b) Equipment rooms shall be sized and equipment arranged to provide adequate clear space for maintenance, inspection, and repair or replacement.

(c) In the selection of equipment and materials of construction that will require maintenance, consideration shall be given to:

1 the availability and cost of replacement materials and parts;

2 needs for special tools;

3 complex equipment that may exceed the capabilities of the maintenance forces;

4 need for equipment manufacturer's technical services.

(2) Systems and Controls. Care shall be exercised in the selection of equipment, and particularly their controls and control systems to assure that unnecessary complexities in operating controls, adjustment features and adjustment requirements, and in the overall control systems' design, are avoided. Over-designed systems from a system-complexity standpoint can often lead to significant problems in the day-to-day operation of completed facilities, and in the maintenance and adjustment requirements for such systems.

(a) For those facilities having hazardous operations, special attention should be given to failure modes of active components in the design of systems and controls. Typical examples of failure modes and effects to be evaluated are:

1 Whether a valve fails to open or close may mean the difference between no consequence or a significant accident.

2 The loss of a feedback transducer in a control circuit could result in the controller producing an unsafe condition.

3 Failure in a power distribution circuit could result in a loss of power to a critical component or system, even though normal power to the remainder of the facility is unaffected.

4 Failure of a noncritical power or control circuit could result in subsequent failure or misoperation of a critical power or control circuit due to "cascading" effect; particularly in the case of complex control system circuitry, power supply interlock systems, "parallel path" control circuits, or "sneak circuits."

(b) Single failures, and common-mode failures, and their effects should be a primary consideration in the design effort for systems having major safety significance. For complex systems, a formal "failure modes and effects analysis" may be needed. For guidance, see ANSI/IEEE 352, "Guide for General Principles of Reliability Analysis of Nuclear Power Generating Station Protective Systems;" particularly the sections that address "Qualitative Analysis."

(3) Use of Operating/Maintenance Knowledge and Experience. During the facility planning and design review activities, maximum use shall be made of the knowledge and experience of those persons who will be responsible for the operation and maintenance of completed facilities. There is no substitute for practical experience and knowledge gained from the operation and maintenance of existing facilities, and it can be of significant value during the planning and design phases. This is particularly true with regard to avoiding downstream problems and not repeating the mistakes made in the planning, design, and construction of other facilities.

(4) Operating and Maintenance Instructions. The requirements and detail of operating and maintenance (O&M) information and data for each facility shall be carefully determined during the planning and design phases, including determination of who shall be responsible for assembling or developing all required information and data. For the larger or more complex projects, the cost for this work can be significant. Estimates for the work need to be included in the total cost estimate for the project.

(a) Many DOE facilities involve a sufficient degree of operating and maintenance complexities to require the formal, structured preparation of complete operating and maintenance manuals. These manuals shall include information, data, and instruction for such facility features as:

1 Mechanical and electrical system equipment and controls;

2 Utility systems equipment and controls;

3 Manufacturing, fabrication, research and development, and other process-type systems;

4 Master equipment lists, catalog data, and warranty data;

5 Equipment manufacturers recommended operating and maintenance procedures;

6 Recommended spare parts lists;

7 Performance and acceptance test procedures and data;

8 Day-to-day operating instruction for all equipment and controls; and

9 Special energy conservation instructions.

(b) Of particular importance for operation and maintenance is the availability of accurate "as built" drawings. Procedures shall be established for periodic revision of the "as-built" drawings. "As built" drawings should clearly identify structural material strengths, live loads, and lateral forces used in the design of the facility. In addition, special attention needs to be given to preparation of instructions for the day-to-day operation of electrical and mechanical systems and controls (manual and automatic); and to reduce energy consumption in buildings and achieve the energy-use design goals.

(c) During development of O&M manuals, consultation with those responsible for facility operation and maintenance is required to assure the resulting manuals are complete and adequate.

(d) The number of required copies of O&M instructions will vary depending upon the operating and maintenance complexities for each facility project and the operating and maintenance organizations' requirements. Because these instructions (manuals) will need to be revised from time-to-time to properly reflect system and equipment changes, it is important to keep their number to the minimum necessary for effective operating and maintenance purposes. As a general rule, no less than 6 copies should be prepared. At least one copy will need to be made a part of the project files or otherwise assigned to a non-use location (stored) for permanent retention for the life of the facility.

n. Decontamination and Decommissioning.

(1) Design of facilities where radioactive or other hazardous contaminating materials will be utilized in, or result from facility operation, shall incorporate measures to limit dispersion and simplify decontamination and ultimate facility decommissioning and disposal or reuse. It is important that careful consideration be given to both the decontamination requirements that may be needed from time-to-time during the operating life of the facility and to the ultimate decontamination requirements prior to decommissioning

and disposal, or conversion to other use. To the extent feasible, these requirements should be identified during the facility planning phase, based upon selection of a tentative decommissioning method or the planned conversion of the facility to other use.

(2) Features and measures to simplify future decontamination that will generally be required include:

(a) Providing walls, ceilings, and floors with suitable washable or strippable paints; or covering with suitable liners.

(b) Caulking (or otherwise finishing off) all cracks, crevices and joints to prevent contamination spread to inaccessible areas.

(c) Use of modular, moveable enclosures for actual work with contaminating materials.

(d) Use of modular radiation shielding, in lieu of or in addition to monolithic shielding walls.

(e) Use of separate contamination barriers within radiation shielding areas to prevent or reduce shielding contamination.

(f) Placing air exhaust filters at or near individual radioactive material (or other contaminant) enclosures to minimize contamination of long sections of exhaust ductwork, and downstream exhaust equipment.

(g) Providing architectural/structural features and other features for ease of dismantlement and removal of contaminated equipment from the facility (e.g., for removal of glove box enclosures, dismantlement and removal of air filtration equipment and ductwork, and other contaminated equipment).

(h) Use of localized liquid transfer systems that avoid long runs of buried contaminated piping, use of localized batch solidification of liquid wastes, and special design/construction methods to assure integrity of joints in liquid transfer piping (particularly buried piping).

o. Building Accessibility and Usability by the Physically Handicapped.

(1) Title 41 CFR, Federal Property Management Regulations (FPMR), Subchapter D, Subpart 101-19.6, "Accommodations for the Physically Handicapped," implementing Public Law 90-480 of 8-12-68, as amended (42 U.S.C. 4151, et seq):

(a) Prescribes standards for design, construction, or alteration of buildings and related facilities, and for leased buildings. These standards shall be applied within the Department of Energy, and by contractors and subcontractors providing facility planning and design services or building acquisition services for the Department, for all applicable buildings or building alterations as defined in the FPMR Subpart 101-19.6.

1 FPMR Subpart 101-19.603, as amended by FPMR Temporary Regulation D-66 of 10-14-80, Temporary Regulation D-66, Supplement 1, of 8-3-81, and most recently Temporary Regulation D-66, Supplement 2, of 8-25-82, identifies the "GSA Accessibility Standard" as the prescribed standard to be followed; pending the development and issuance of a new "Federal Accessibility Standard" by GSA and three other Federal Agencies (The Department of Housing and Urban Development, The Department of Defense, and the United States Postal Service).

2 See paragraph 13, "Facility Design for the Physically Handicapped," in Chapter IV of this Order for criteria on implementation of Public Law 90-480 and FPMR Subpart 101-19.6 requirements, and application of the prescribed standards.

(b) Prescribes requirements for recordkeeping. Documentation by Departmental Elements responsible for design, construction, alteration, or lease of buildings and related facilities shall be in accordance with FPMR Subpart 101-19.606 requirements.

(c) Prescribes requirements for semiannual reporting to GSA during design and construction, and for leased buildings, on all facilities subject to the FPMR Subpart 101-19.603 prescribed standards.

1 The Headquarters' Construction and Facilities Management Division, Office of Project Facilities Management, is responsible for developing the composite DOE semiannual reports from feeder reports provided by the responsible Departmental field elements, and for submittal of these reports to the General Services Administration (GSA) by March 15 and September 15 of each year.

2 All feeder reports from Departmental Elements to the Construction and Facilities Management Division shall be due no later than the fifth working day following the end of February and August of each year.

3 Feeder reports shall be prepared on GSA Form 2974, "Status Report for Federally Funded Buildings-Accommodation of Physically Handicapped," for design-construction projects that are subject to the requirements of the FPMR and the prescribed standards, therein, and that were under design (Title I or Title II design) or construction during the 6-month reporting period. GSA Form 2974A, "Accessibility to

the Physically Handicapped in Leased Buildings," shall be used for all buildings leased, or building lease renewals, by the Department during the 6-month reporting period. Buildings or space obtained through GSA shall be excluded from these reporting requirements.

(2) Advice and guidance on implementation of the above reporting requirements, copies of the GSA reporting Forms 2974 and 2974A, and copies of the GSA-prescribed standards, may be obtained by request to the Construction and Facilities Management Division.

(3) In determining the applicability of the prescribed standards in FPMR Subpart 101-19.6 (as amended) to the design of DOE facilities or to leased buildings, careful consideration needs to be given as to whether the buildings intended use will require either that the facility be accessible to the public or may result in the employment therein of physically handicapped persons (paraphrased from Public Law 90-480 and FPMR 101-19.6). Particular attention shall be given as to whether the intended use "may result in the employment therein of physically handicapped persons." No exemptions shall be taken from the application of the prescribed standards for any facility solely on the basis that the facility is not, or will not be, accessible to the public.

(a) Since the enactment of P.L. 90-480 and promulgation of FPMR Subpart 101-19.6, at least two other public laws have been enacted in regard to employment of handicapped persons. The Rehabilitation Act of 1973 and the Vietnam Era Veterans' Readjustment Act of 1974 have mandated an extensive program of affirmative action and a policy of nondiscrimination in the employment of the handicapped and disabled veterans. As a part of the Department's overall effort in supporting the employment of handicapped individuals and disabled veterans, the DOE affirmative action program includes a commitment to affirmative action in the removal of architectural barriers, wherever practicable.

(b) "Affirmative Action Obligations of Contractors and Subcontractors for Disabled Veterans and Veterans of the Vietnam Era" are contained in 41 CFR Part 60-250. In addition, "Affirmative Action Obligations of Contractors and Subcontractors for Handicapped Workers" are contained in 41 CFR Part 60-741. For the Department's contractors or subcontractors that occupy Government-owned or leased facilities, it is important to recognize that their satisfaction of affirmative action requirements with relation to employment of these groups can be dependent upon the degree of accessibility and useability of the facilities that they occupy.

(4) See Chapter IV for additional criteria on facility design for physically handicapped persons.

p. Use of the Metric System. Pending issuance of additional general design criteria on use of the metric system to implement applicable requirements in DOE 5900.2, USE OF THE METRIC SYSTEM OF MEASUREMENT, of 12-19-80, Departmental organizations are encouraged to consider, on a voluntary basis, increased use of the metric system where it may be deemed feasible and advantageous.

(1) Background.

(a) The Metric Conversion Act of 1975 (89 Stat. 1007), Public Law 94-168 (15 U.S.C. 205a) declares that the policy of the United States shall be to coordinate and plan the increasing use of the metric system in the United States. That Public Law also established the U.S. Metric Board to coordinate the voluntary conversion to the metric system.

(b) The "Metric Conversion System for Federal Agencies," approved by the Interagency Committee on Metric Policy on 6-11-79, states the policy for the increasing use of the metric system within the Federal Government.

(2) Sources of Information.

(a) "The Metric System of Measurement," published in the Federal Register Notice of 10-27-77, interprets and modifies the International System of Units (SI), for the United States. A chart is included that shows the relationships of all the SI to which names have been assigned.

(b) National Bureau of Standards (NBS) special Publication 330, 1977 (or later) edition, "The International System of Units (SI)."

(c) NBS, "Preferred Metric Units for General Use by Federal Government," Letter Circular LC 1098 of 11-78. These preferred metric units were developed by the Metric Practice and Preferred Units Division of the Operating Committee, of the Interagency Committee of Metric Policy.

(d) ANSI/ASTM E380-76/IEEE 268-1976, "Standard for Metric Practice" which gives guidance for application of the modernized metric system in the United States.

(e) "Federal Agency Guidelines for Implementation of Metric Conversion Policy," by the Interagency Committee on Metric Policy, approved 10-25-79. These guidelines clarify the basic Federal policy and assist in the development and coordination of cost-effective metrication activities and programs.

(f) "Metric Editorial Guide," Third Edition, 1978, American National Metric Council, which provides a set of recommendations of accepted metric practices.

(g) DOE 5900.2, USE OF THE METRIC SYSTEM OF MEASUREMENT, of 12-19-80.

(h) For further information, contact the Office of Quality Assurance and Standards, at DOE Headquarters.

q. Protective Construction and Emergency Preparedness Facilities.

(1) General criteria for structural design to increase the resistance of buildings and other structures to safely withstand the effects of nuclear weapons, as were being applied in DOE predecessor organizations, are under review for possible updating, revision, and reissuance as DOE general design criteria.

(2) General design criteria for fallout shelters and for emergency operating centers are under review for possible updating, revision, and reissuance as DOE general design criteria. However, basic design criteria for fallout shelters (personnel shelters) are identified in paragraph 15 of Chapter IV of this Order for continued application.

(3) In updating and revising these design criteria, advice and assistance will be needed from Departmental Elements having responsibilities in the areas of DOE emergency management/emergency preparedness programs and functions to best satisfy the Department's policies and objectives and facility needs as identified in DOE 5500.2, EMERGENCY PLANNING, PREPAREDNESS, AND RESPONSE FOR OPERATIONS, of 8-13-81, and DOE 5500.3, REACTOR AND NONREACTOR NUCLEAR FACILITY EMERGENCY PLANNING, PREPAREDNESS, AND RESPONSE PROGRAM FOR DOE OPERATIONS, of 8-13-81; and the applicable emergency management requirements established and promulgated by the Federal Emergency Management Agency.

r. Construction Specifications. In developing specifications for construction work, the Federal Construction Guide Specifications (FCGS) of the Federal Construction Council may be used for guidance. For information on the FCGS program, contact the Office of Project and Facilities Management at DOE Headquarters.

LISTING OF OTHER DOE ORDERS TO BE FOLLOWED IN THE PLANNING AND DESIGN, OR ACQUISITION, OF DOE FACILITIES (use the latest editions and changes)

1. DOE 1360.1, ACQUISITION AND MANAGEMENT OF AUTOMATIC DATA PROCESSING EQUIPMENT AND RESOURCES, of 8-9-78, which establishes policies and procedures for the acquisition and management of automatic data processing equipment and resources.

2. DOE 1360.2, COMPUTER SECURITY PROGRAM FOR UNCLASSIFIED COMPUTER SYSTEMS, of 3-9-79, which establishes policies and procedures for developing, implementing and administering a program for safeguarding unclassified computer systems.

3. DOE 3790.1, OCCUPATIONAL SAFETY AND HEALTH PROGRAM FOR FEDERAL EMPLOYEES, of 12-11-80, which establishes the policy for the implementation and administration of the occupational, safety, and health program for Federal employees.

4. DOE 3900.1, PARKING, of 11-19-79, which prescribes policies and procedures governing the acquisition, allocation, and use of Federal parking facilities by Federal employees, contractor employees, and other facility tenants.

5. DOE 4300.1A, REAL ESTATE (REAL PROPERTY) MANAGEMENT, of 7-7-83, which establishes policies and procedures for the acquisition, use, and disposal of real estate or interests therein; including requirements and procedures for site investigations and site selections.

6. DOE 4320.1A, SITE DEVELOPMENT AND FACILITY UTILIZATION PLANNING, of 3-17-83, which establishes policies and procedures for site development and facility utilization planning.

7. DOE 4330.2A, IN-HOUSE ENERGY MANAGEMENT PROGRAM, of 2-16-82, which prescribes policies and procedures for establishment and implementation of the Department's in-house energy management program; including retrofit of buildings and other facilities and fuel conversions.

8. DOE 4330.3, FUELS AND ENERGY USE POLICY, of 10-22-80, which provides policy and general guidance for the selection and use of fuels and forms of energy in Department of Energy owned facilities.

9. DOE 5300.1A, TELECOMMUNICATIONS, of 11-16-81, which estabishes policy and general guidance for Departmental telecommunications services.

10. DOE 5300.2A, TELECOMMUNICATIONS: EMISSION SECURITY (TEMPEST), of 8-30-82, which establishes the Departmental program for emission security and implements provisions of the national policy which are applicable to emission security.

11. DOE 5300.3A, TELECOMMUNICATIONS: COMMUNICATIONS SECURITY, of 12-7-83, which establishes policy and provides guidance concerning the communications security aspects of the Department's telecommunications services, and implements the national telecommunications protection policy.

12. DOE 5300.4, TELECOMMUNICATIONS: PROTECTED DISTRIBUTION SYSTEMS, of 10-28-81, which establishes policy for protected distribution systems used to process classified or sensitive unclassified information related to national security.

13. DOE 5310.1A, TELECOMMUNICATIONS: DATA COMMUNICATIONS FACILITIES, SERVICES, AND EQUIPMENT, of 9-3-82, which provides procedures and guidelines for planning, engineering, proposing, and reporting of Department of Energy and contractors' data, facsimile, and narrative message communications facilities, services, and equipment.

14. DOE 5320.1A, TELECOMMUNICATIONS: SPECTRUM DEPENDENT SERVICES, of 9-21-81, which prescribes policies, responsibilities, and guidance for management of radiocommunications and electromagnetic resources throughout the Department and its contractor facilities.

15. DOE 5330.1, TELECOMMUNICATIONS: TELEPHONE SERVICES, OF 7-31-80, which provides guidance for managing and operating telephone services for the Department of Energy and its contractors; including planning, engineering, and acquiring telephone services and systems.

16. DOE 5420.1, ENVIRONMENTAL DEVELOPMENT PLANS, of 8-10-78, which establishes policy and general procedures for the Department of Energy Environmental Development Plan system, applicable to organizational elements which manage energy programs.

17. DOE 5440.1B, IMPLEMENTATION OF THE NATIONAL ENVIRONMENTAL POLICY ACT, of 5-14-82, which establishes procedures for implementing the National Environmental Policy Act of 1969.

18. DOE 5480.1A, ENVIRONMENTAL PROTECTION SAFETY, AND HEALTH PROTECTION PROGRAM FOR DOE OPERATIONS, of 8-13-81, which establishes the environmental protection, safety, and health protection program for Department of Energy operations with specific chapters as follow:

Chapter	Title and Coverage
I	"Environmental Protection, Safety and Health Protection Standards," of 8-13-81, which sets forth the environmental protection, safety, and health protection standards applicable to all operations of the Department of Energy.
III	"Safety Requirements for the Packaging of Fissile and Other Radioactive Materials," of 5-1-81, which establishes requirements for the packaging of fissile and other radioactive materials.
IV	"Nuclear Criticality Safety," of 5-1-81, which establishes safety procedures and requirements for the Department of Energy owned nuclear facilities with respect to nuclear criticality safety.
V	"Safety of Nuclear Facilities," of 8-13-81, which establishes safety procedures and requirements for nuclear facilities with respect to the siting, design, construction, modification, operation, maintenance, and decommissioning of such facilities.
VII	"Fire Protection," of 12-18-80, which establishes requirements for an improved risk level of fire protection for Department of Energy facilities; or a higher standard of protection as may be justified for the purpose of national security, program continuity, or protection of the public.
VIII	"Contractor Occupational Medical Program," of 5-22-81, which establishes minimum occupational medical program requirements for Department of Energy contractors, including minimum facilities and equipment requirements.
X	"Industrial Hygiene Program," of 5-22-81, which establishes requirements and guidance for maintaining an effective industrial hygiene program, including facilities and instrumentation needed to implement these requirements.
XI	"Requirements for Radiation Protection," of 8-13-81, which establishes radiation protection standards and requirements for Department of Energy and contractor operations, based on the recommendations of the Environmental Protection Agency and the National Council on Radiation Protection and Measurement; and includes facility design and construction considerations.
XII	"Prevention, Control and Abatement of Environmental Pollution," of 12-18-80, which establishes requirements for Department of Energy Operations to assure control of sources of environmental pollution, and compliance with Federal environmental protection laws and with Executive Order 12088, "Federal Compliance with Pollution Control Standards."

19. DOE 5481.1A, SAFETY ANALYSIS AND REVIEW SYSTEM, of 8-13-81, which establishes requirements for the preparation and review of safety analyses of Department of Energy operations, including the identification of hazards, their elimination or control, assessment of the risk, and documented management authorization of the operation.

20. DOE 5483.1A, OCCUPATIONAL SAFETY AND HEALTH PROGRAM FOR GOVERNMENT-OWNED CONTRACTOR-OPERATED FACILITIES, of 6-22-83, which provides guidance and establishes procedures to assure that contractor employees in Government-owned facilities are provided with safe and healthful working conditions in accordance with standards which are at least as effective as those promulgated under the Occupational Safety and Health Act of 1970.

21. DOE 5500.2, EMERGENCY PLANNING, PREPAREDNESS, AND RESPONSE FOR OPERATIONS, of 8-13-81, which provides for the coordination and direction of Department of Energy planning, preparedness, and response to operational emergencies; including requirements for emergency facilities and equipment.

22. DOE 5500.3, REACTOR AND NONREACTOR NUCLEAR FACILITY EMERGENCY PLANNING, PREPAREDNESS, AND RESPONSE PROGRAM FOR DEPARTMENT OF ENERGY OPERATIONS, of 8-13-81, which establishes requirements for the development of Department of Energy site specific emergency plans and procedures for radiological emergencies occurring in existing or planned DOE reactors and nonreactor facilities; including requirements for emergency facilities and equipment.

23. DOE 5610.1, PACKAGING AND TRANSPORTING OF NUCLEAR EXPLOSIVES, NUCLEAR COMPONENTS, AND SPECIAL ASSEMBLIES, of 9-11-79, which establishes policy and assigns responsibilities and authorities for the packaging and transporting of nuclear explosives, nuclear components, and special assemblies; including requirements for development and issuance of criteria and procedures for the safe packaging and transporting of nuclear components and special assemblies.

24. DOE 5630.1, CONTROL AND ACCOUNTABILITY OF NUCLEAR MATERIALS, of 8-3-79, which provides material control and accountability subsystems for special nuclear materials which complement the physical protection subsystems outlined in other Department of Energy Orders in the 5630 series that collectively comprise the DOE safeguards program to guard against the theft or unauthorized diversion of special nuclear materials.

25. DOE 5630.2, CONTROL AND ACCOUNTABILITY OF NUCLEAR MATERIALS, BASIC PRINCIPLES, of 8-21-80, which contains the basic principles and requirements for control and accountability of nuclear materials.

26. DOE 5632.1, PHYSICAL PROTECTION OF CLASSIFIED MATTER, of 7-18-79, which prescribes policies and objectives for the physical protection of classified matter.

27. DOE 5632.2, PHYSICAL PROTECTION OF SPECIAL NUCLEAR MATERIALS, of 2-16-79, which establishes minimum physical protection standards for special nuclear materials.

29. DOE 5636.2, SECURITY REQUIREMENTS FOR CLASSIFIED AUTOMATIC DATA PROCESSING SYSTEMS, of 1-10-80, which establishes requirements, policies, and responsibilities for the development and implementation of a Department of Energy program to assure the security of information stored in classified automated data processing systems; including requirements for physical security protection of classified systems.

30. DOE 5700.4, PROJECT MANAGEMENT SYSTEM, of 1-8-81, which provides detailed guidance and procedures for implementation of the Department's project management system.

31. DOE 5700.6A, QUALITY ASSURANCE, of 8-13-81, which provides Department of Energy policy, sets forth principles, and assigns responsibilities for establishing, implementing, and maintaining programs of plans and actions to assure quality achievement in DOE programs; including those directed toward siting, design, construction, testing, operation, maintenance, and decommissioning of facilities.

32. DOE 5900.2, USE OF THE METRIC SYSTEM OF MEASUREMENT, of 12-19-80, which establishes policies and objectives for the development and implementation of the metrication program of the Department of Energy; including requirements for use of the metric system where feasible in the design of new components, systems, plants, and facilities.

33. DOE 6410.1, MANAGEMENT OF CONSTRUCTION PROJECTS, of 5-26-83, which establishes policy and procedures to be followed in the planning, design, and construction of the Department's facilities.

REFERENCE MATERIAL SOURCES

Acoustical Materials Association
335 East 45th Street
New York, New York 10017

Air-Conditioning and Refrigeration
Institute (ARI)
1815 N. Fort Meyer Drive
Arlington, Virginia 22209

Air-Moving and Conditioning
Association (AMCA)
30 West University Drive
Arlington Heights, Illinois 60004

The Aluminum Association
750 Third Avenue
New York, New York 10017

American Association of State Highway
and Transportation Officials (AASHTO)
444 North Captiol Street
Washington, D.C. 20001

American Boiler Manufacturers
Association (ABMA)
1500 Wilson Boulevard
Arlington, Virginia 22209

American Concrete Institute (ACI)
Publications Sales Department
P.O. Box 7454, Redford Station
Detroit, Michigan 48219

American Concrete Pipe Association
(ACPA)
8320 Old Courthouse Road
Vienna, Virginia 22180

American Conference of Governmental
Industrial Hygienists (ACGIH)
1014 Broadway
Cincinnati, Ohio 45202

American Gas Association (AGA)
1515 Wilson Boulevard
Arlington, Virginia 22209

American Industrial Hygiene
Association (AIHA)
475 Wolf Ledges Parkway
Akron, Ohio 44311

American Institute of Chemical Engineers
(AICE)
345 East 47th Street
New York, New York 10017

American Institute of Steel
Construction (AISC)
400 North Michigan Avenue
Chicago, Illinois 60611

American Institute of Timber Construction
(AITC)
1700 K Street, N.W.
Washington, D.C. 20006

American Insurance Association (AIA)
85 John Street
New York, New York 10038

American Iron and Steel Institute (AISI)
633 Third Avenue
New York, New York 10017

American National Standards Institute
(ANSI)
1430 Broadway
New York, New York 10018

American Petroleum Institute (API)
2101 L Street
Washington, D.C. 20037

American Railway Engineering Association
(AREA)
59 East Van Buren Street
Chicago, Illinois 60605

American Society of Civil Engineers (ASCE)
345 E. 47th Street
New York, New York 10017

American Society of Heating,
Refrigerating, and Air-Conditioning
Engineers, Inc. (ASHRAE)
345 E. 47th Steet
New York, New York 10017

American Society of Mechanical
Engineers (ASME)
345 E. 47th Street
New York, New York 10017

American Society of Plumbing
Engineers (ASPE)
16161 Ventura Boulevard, Suite 105
Encino, California 91316

American Society of Quality Control (ASQC)
230 Well Street
Milwaukee, Wisconsin 53203

American Society for Testing and
Materials (ASTM)
1916 Race Street
Philadelphia, Pennsylvania 19103

American Waterworks Association
(AWWA)
666 Quincy Street
Denver, Colorado 80235

American Welding Society (AWS)
2510 N.W. 7th Street
Miami, Florida 33125

American Wood Preservers
Association (AWPA)
1625 I Street, N.W.
Washington, D.C. 20006

Associated Air Balance Council (AABC)
2146 Sunset Boulevard
Los Angeles, California 90026

Cast Iron Pipe Research Association
Suite 3440, Prudential Plaza
Chicago, Illinois 60601

Compressed Gas Association (CGA)
500 Fifth Avenue
New York, New York 10036

Cooling Tower Institute (CTI)
3003 Yale Street
Houston, Texas 77018

U.S. Department of Labor
OSHA Publications office
Third Street and Constitution
Avenue, N.W.
Washington, D.C. 20210

Edison Electric Institute (EEI)
90 Park Avenue
New York, New York 10016

U.S. Environmental Protection
Agency (EPA)
401 M Street, N.W.
Washington, D.C. 20460

Factory Mutual Engineering Division
1151 Boston-Providence Turnpike
Norwood, Massachusetts 02062

Federal Construction Council
(See National Academy of Sciences)

Heat Exchange Institute (HEI)
122 E. 42nd Street
New York, New York 10017

Hydronics Institute (HI)
35 Russo Place
Berkeley Heights, New Jersey 07922

Illuminating Engineering Society (IES)
345 E. 47 Street
New York, New York 10017

Incinerator Institute of America (IIA)
60 E. 42nd Street
New York, New York 10017

Institute of Electrical and Electronics
Engineers, Inc. (IEEE)
345 E. 47th Street
New York, New York 10017

Institute of Industrial Engineers (IIE)
25 Technology Park/Atlanta
Norcross, Georgia 30092

Instrument Society of America (ISA)
400 Stanwix Street
Pittsburgh, Pennsylvania 15222

Insulated Cable Engineers Association (ICEA)
283 Valley Road
Montclair, New Jersey 07042

International Conference of Building Official (ICOBA)
Uniform Building Code
5360 South Workman Mill Road
Whittier, California 90601

International District Heating Association (IDHA)
5940 Baum Square
Pittsburgh, Pennsylvania 15206

Mechanical Contractors Association of America (MCAA)
2 Pennsylvania Avenue
New York, New York 10017

Metal Building Manufacturers Association (MBMA)
2130 Keith Building
Cleveland, Ohio 44115

National Academy of Sciences (NAS)
Federal Construction Council (FCC)
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

National Association of Plumbing-Heating-Cooling Contractors (NAPHC)
1016 20th Street, N.W.
Washington, D.C. 20036

National Bureau of Standards (NBS)
U.S. Department of Commerce
Washington, D.C. 20234

National Clay Pipe Institute (NCPI)
1130 17th Street, N.W.
Washington, D.C. 20036

National Concrete Masonry Association (NCMA)
1800 N. Kent Street
Arlington, Virginia 22209

National Electrical Manufacturers Association (NEMA)
155 E. 44th Street
New York, New York 10017

National Environmental Balancing Bureau (NEBB)
1611 North Kent Street
Arlington, Virginia 22209

National Environmental Systems Contractor Association (NESCA)
1501 Wilson Boulevard
Arlington, Virginia 22209

National Fire Protection Association (NFPA)
Batterymarch Park
Quincy, Massachusetts 02269

National Forest Products Association
1619 Massachusetts Avenue, N.W.
Washington, D.C. 20036

National Oceanic and Atmospheric Administration (NOAA)
National Climatic Center
Federal Building
Asheville, North Carolina 28801

National Roofing Contractors Association (NRCA)
1001 Connecticut Avenue, N.W.
Washington, D.C. 20036

National Safety Council (NSC)
444 N. Michigan Avenue
Chicago, Illinois 60611

Portland Cement Association (PCA)
Old Orchard Road
Skokie, Illinois 60076

Sheet Metal and Air-Conditioning Contractors National Association (SMACNA)
8224 Old Courthouse Road
Tysons Corner
Vienna, Virginia 22180

Southern Building Code Congress
International, Inc. (SBCC)
Standard Building Code
1116 Brown-Marx Building
Birmingham, Alabama 35203

Steel Boiler Institute (SBI)
Division of IBR, Hydronics Institute
35 Russo Way
Berkley Heights, New Jersey 07922

Steel Joist Institute (SJI)
2001 Jefferson Davis Highway
Arlington, Virginia 22202

Stoker Manufacturers Association
(SMA)
307 N. Michigan Avenue
Chicago, Illinois 60601

Structural Clay Products Institute
(SCPI)
1750 Old Meadow Road
McLean, Virginia 22101

Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402

Thermal Insulation Manufacturing
Association (TIMA)
7 Kirby Plaza
Mt. Kisco, New York 10549

Tubular Exchanger Manufacturers
Association (TEMA)
331 Madison Avenue
New York, New York 10017

Underwriters Laboratories (UL)
33 Pfingston Road
Northbrook, Illinois 60062

Water Pollution Control Federation (WPCF)
3900 Wisconsin Avenue, N.W.
Washington, D.C. 20016

CHAPTER II

R E S E R V E D

(SITE AND CIVIL ENGINEERING)

TO BE ISSUED

CHAPTER III

R E S E R V E D

CHAPTER IV

ARCHITECTURAL AND STRUCTURAL

1. COVERAGE. These criteria, together with applicable criteria in Chapter I, Chapter X and Chapter XIII shall be applied in architectural and structural planning, design of buildings and other structures. Additional criteria for specific types of facilities are contained in other chapters of this Order, beginning with Chapter XVI. It is recognized that expansion in coverage of both the architectural and structural criteria will be necessary to best satisfy DOE requirements and user needs. These future expansions are planned with technical input, advice, and assistance from other DOE organizations and from the users of the criteria having particular expertise in the architectural and structural design areas. It is also planned to separate these criteria into individual chapters. Chapter III has been reserved for the expanded architectural criteria, and this Chapter IV will contain the expanded structural criteria.

2. CODES, STANDARDS, AND GUIDES. In addition to the basic building codes identified in paragraph 3a, in Chapter I, the latest editions of the codes, standards, and guides listed below shall also be followed:

   a. Structural Materials.

      (1) Aluminum. "Aluminum Construction Manual," The Aluminum Association.

      (2) Concrete.

         (a) "Building Code Requirements for Reinforced Concrete," ACI 318, American Concrete Institute.

         (b) "Practice for Concrete Floor and Slab Construction," ANSI/ACI 302.

         (c) "Code Requirements for Nuclear Safety Related Concrete Structures," ANSI/ACI 349.

         (d) Prestressed Concrete Institute Standards.

      (3) Masonry.

         (a) "Building Code Requirements for Concrete Masonry Structures," ANSI/ACI 531.

         (b) "Building Code Requirements for Masonry," ANSI/NBS 211.

         (c) "Building Code Requirements for Reinforced Masonry," ANSI/NBS Handbook H74.

(d) "Recommended Building Code Requirements for Engineered Brick Masonry," Structural Clay Products Institute.

(e) "Specification for the Design and Construction of Load Bearing Concrete Masonry," National Concrete Masonry Association.

(4) Structural Steel. "Specification for Design, Fabrication, and Erection of Structural Steel for Buildings," American Institute of Steel Construction.

(5) Steel Joists and Joist Girders. "Standard Specifications, Load Tables and Weight Tables for Steel Joists and Joist Girders," Steel Joist Institute.

(6) Steel Decks.

(a) "Steel Deck Design Manual for Composite Decks, Form Decks and Roof Decks," Steel Deck Institute.

(b) "Steel Deck Institute Diaphram Design Manual."

(7) Steel, Light Gauge. "Specifications for the Design of Light Gauge Cold-Formed Steel Structural Members," American Iron and Steel Institute.

(8) Structural Lumber. "National Design Specifications for Stress Grade Lumber and Its Fastenings," National Forest Products Association.

(9) When designing structural members of the above materials for seismic loadings, the provisions of the Uniform Building Code (UBC) regarding design considerations and allowable unit stresses shall usually govern. See paragraph 3a(2) in Chapter I of this Order.

b. Pressure Treatment of Wood Products. "Standards for Pressure Treated Lumber," American Wood Preservers Association.

c. Welding. Welding of structural steel shall be in accordance with the requirements of the "Structural Welding Code," AWS D1.1, American Welding Society.

d. Building Design Loads. "Building Code Requirements for Minimum Design Loads in Buildings and Other Structures," ANSI A58.1.

e. Preengineered Metal Buildings. "Metal Building Systems Manual," Metal Building Manufacturers Association.

f. Fire Protection. See Chapter X, "Fire Protection," for applicable codes, standards and guides.

g. Seismic Design. "Uniform Building Code," International Conference of Building Officials.

h. Wind and Seismic Lateral Force Design. "Seismic Design for Buildings," TM 5-809-10, U.S. Department of the Army. (Lateral force design methodologies in this Technical Manual can be used effectively for wind design as well as seismic design.)

i. Bridge Structures.

(1) Highway Bridges. "Standard Specifications for Highway Bridges," American Association of State Highway and Transportation Officials.

(2) Railway Bridges. "Manual of Recommended Practices," American Railway Engineering Association.

j. Elevated Steel Water Tanks, Standpipes, and Reservoirs. American Water Works Association standards and NFPA 22, "Water Tanks for Private Fire Protection."

k. Building Roofs, Flashing, and Drainage.

(1) "Roofing Manual," National Roofing Contractors Association.

(2) "Architectural Sheet Metal Manual," Sheet Metal and Air Conditioning Contractors National Association.

(3) Factory Mutual (FM) Loss Prevention Data Sheet 1-28, "Insulated Steel Deck."

3. DESIGN QUALITY.

a. Architectural and engineering design shall be both functional and cost effective. Individual facility designs shall be carefully tailored to fit their intended functional use, but with emphasis on the selection of low maintenance and energy efficient features. Special attention shall be given to selecting appropriately sized HVAC systems that are easily maintained and are located in accessible areas of the facility; low maintenance interior and exterior surfaces; and quality roofing systems. Strong consideration shall also be given to coordinating the architectural features of new facilities with the existing architecture at the site in order to promote an orderly and efficient appearance.

b. It is important that there be close coordination in development of architectural, structural, and mechanical features to ensure compatibility with planned functional equipment and to facilitate constructability.

4. SPACE PLANNING. Systematic and thorough space planning is an essential element of the building planning process, and shall be performed to assure that buildings will satisfy programmatic and operating requirements in an optimum manner, with maximum utilization of the total space.

a. Effective space planning and arrangement begins with a clear identification of building functions, occupancy requirements, interrelationship of functions and activities, internal and external circulation, building equipment and services' space requirements, research and development and operating space requirements, and other space requirements.

b. Space layouts, including alternatives, when necessary, shall be developed during the project planning (conceptual design) phase, and utilized in establishing the building size, configuration, and other building features. Safe building access, egress, and internal traffic flow are important objectives in space layout. Input on space requirements shall be obtained from the building users, and space layouts shall be fully coordinated with the users.

c. Space layouts shall be further refined during follow-on preliminary (Title I) design, as necessary. To the maximum extent feasible, space layouts should be finalized by the end of Title I design, to minimize design changes and design delays during detailed (Title II) design.

d. Layouts shall be developed with efficiency and flexibility as principal considerations. Standard work space modules, which permit repetition in subdivision of space, should be developed to satisfy program or operating requirements. Unpartitioned, open spaces should be used to the greatest extent practicable.

e. Maximum utilization of space shall be a primary objective. Wasted space through inefficient corridor layout, unnecessary lobbies, and monumental spaces shall be avoided. Building designs shall be developed to achieve the maximum practicable efficiency ratio of total net usable area to total gross area. For example, for office/administration type buildings, the design goal should be to achieve an efficiency ratio of not less than 70 percent. See Attachment IV-1 for the method of computing building gross area and net usable area, and building gross volume.

f. In the planning of office and administrative space, the requirements of Federal Property Management Regulation (FPMR), Subchapter D, Part 101-17 (Assignment and Utilization of Space) shall be followed. Section 101-17.3, "Space Standards, Criteria, and Guidelines," contains area allowances to be utilized in space planning. It is also important that there be consistency between the area allowances utilized in the planning and design of new DOE buildings and building additions and those promulgated in DOE 4300.1A, REAL ESTATE (REAL PROPERTY) MANAGEMENT, of 7-7-83, and for other of the Department's leased buildings or space. The same type of consistency is also important with regard to space planning for Government-owned (or leased), contractor-occupied space (i.e., comparability in space allowances for contractor and DOE employees).

g. Where open-office concepts are applied, special attention shall be given to acoustic treatment, illumination, HVAC systems, privacy needs, and furnishings that are compatible with these concepts.

5. BUILDING TYPE.

a. Selection of the building type will depend on such factors as programmatic and operating requirements, anticipated life expectancy, minimum life-cycle cost objectives, compatibility with surrounding buildings and facilities, and health, safety, and fire protection requirements.

b. Where conditions permit (including architectural compatibility with surrounding buildings and facilities, structural adequacy for the expected loads, adequacy for functions to be housed and required facility life, satisfaction of energy conservation and minimum life cycle cost objectives), consideration shall be given to the use of preengineered metal buildings in lieu of more permanent building construction. Preengineered metal buildings shall be designed and constructed in accordance with the "Metal Building Systems Manual," of the Metal Building Manufacturers Association, except that the design loads shall comply with paragraph 9, "Building Design Loads," below.

c. Additions to existing buildings shall not result in reduction of the required fire rating for the existing building.

6. BUILDING LOCATION.

a. The siting of new buildings and building additions shall be consistent with the overall Site Development Plan (or Master Plan). In the event that for some reason, such as lack of currency, the Site Development Plan does not reflect the best site for a proposed facility, the best course is to initiate a site development plan change. Alternatively, if time does not permit a change to be processed, an approved waiver of plan's provisions should be sought from the cognizant field organization or outlay program manager as appropriate.

b. In locating buildings, consideration shall be given to architectural and functional compatibility with the surrounding environment; functional interrelationships; natural topographic and geologic conditions; availability of existing utility services; availability of existing road systems and traffic volume; adequacy for parking and other land use requirements, including expansion capability; health, safety, and environmental protection requirements; and safeguards and security requirements. See Chapter I, paragraph 3.i., for additional facility siting criteria.

7. BUILDING CONFIGURATION. The building shape, single vs. multi-story characteristics, for example, will be dependent on such factors as space layout requirements for the functions to be housed, land availability, building foundation conditions, life-cycle cost, energy conservation requirements, and architectural compatibility with the surrounding environment.

8. BUILDING ORIENTATION. The orientation of buildings can be a significant energy conservation factor with regard to optimizing the benefits from utilization of available solar insolation for building heating, and with regard to optimizing natural ventilation. Building orientation shall be evaluated from this energy conservation standpoint. Generally, the principal building facade should face within 30 degrees of due south to take advantage of the radiant energy of the low winter sun. Overhangs and strategic landscaping should be considered in mitigating the unwanted effects of the summer sun. It must be recognized, however, that building orientation is only one of a number of interrelated factors to be evaluated. Building siting, configuration, fenestration, construction materials and construction features, site landscaping, and internal building space arrangements are other factors that also need to be evaluated in the application of passive solar concepts.

9. BUILDING DESIGN LOADS. Except as otherwise specified below, the loadings used in structural design of buildings and other structures shall comply with the latest edition of ANSI A58.1, "American National Standard Building Code Requirements for Minimum Design Loads in Buildings and Other Structures."

a. Dead Loads. Dead loads include the weight of all permanent construction and all fixed equipment. Loads shall be accurately determined and initial assumed loads for structural members shall be revised in the final design to reflect completed construction requirements with appropriate allowance for any additional loadings likely to be added at a later date.

b. Live Loads.

(1) Floor, roof, and wind loads recommended in ANSI A58.1 shall be considered as minimum requirements, and shall be appropriately increased for local conditions such as higher wind or snow loads experienced at the site. Criteria for site-specific earthquake, tornado loadings, and internal shocks loadings are contained in paragraphs c, d, and e, below.

(2) Selection of the proper "basic wind speed" and facility "exposure" are prerequisites to the use of the wind pressure tables and design methodologies contained in ANSI A58.1.

(a) Extreme wind speed data at the various mean recurrence levels (or return periods) up to 10^4-years may be obtained from the National Oceanic and Atmospheric Administration (NOAA). Requests should be directed to the NOAA Environmental Data Service, National Climatic Center, Federal Building, Asheville, NC, 28801.

(b) The "basic wind speed" to be used in structural design of each facility will be dependent upon such factors as projected facility life, value of the facility including contents, type of operations and requirements for operating continuity, and the hazards of the operations and the materials to be handled or stored within the facility. Wind speed selections shall be based on the appropriate "mean recurrence level" (or mean return period) for each facility. Pending completion and promulgation of the DOE site-specific wind hazard models and guidance (users manual) for their application as discussed in paragraph 9f, below, the following mean recurrence level criteria are provided for interim guidance. These mean recurrence level criteria have been patterned from criteria that have been in use by one of the DOE operations offices since 1975, and generally reflect the types of facility requirements associated with the particular programmatic or operating needs. However, they can also be appropriate for other types of facilities having comparable degrees of hazard, mission-dependent purposes, or dollar value. Engineering judgment needs to be used in the application of these criteria.

1 25-Year Mean Recurrence Level--for small, low-value buildings that are generally valued at less than $500,000 (including contents), entirely for a non mission-dependent purpose, do not pose a threat to human life (high-wind warning system required if occupied), classified as limited-use buildings, and not suitable for alteration to a "substantially-constructed" building.

2 50-Year Mean Recurrence Level--for relatively low-value buildings such as administration buildings, cafeterias, maintenance and repair shops, and laboratories that have a non mission-dependent purpose and/or where the value (including contents) generally does not exceed $2 million.

3 100-Year Mean Recurrence Level--for buildings of greater value and importance such as laboratories, production facilities, and high explosives processing and storage facilities (no radioactive material present) that have a mission-dependent purpose and/or where the value (including contents) is greater than $2 million but generally does not exceed $30 million.

4 1,000-Year Mean Recurrence Level--for buildings of high value or where containment of contents is necessary for public or employee protection. Examples of facilities covered would be high explosives facilities or other facilities involving the handling or storage of significant quantities of radioactive materials, carcinogens, doping agents, or flammable liquids, having mission-dependent purposes (including missions critical to national defense) and/or where the value (including contents) generally exceeds $30 million. For these facilities, design loading requirements may include design basis tornado, seismic, and blast parameters (for explosives facilities), which may also need to be satisfied.

5 10,000-Year Mean Recurrence Level--for high-hazard, high-value buildings where operating continuity and public and employee protection are of paramount importance, such as facilities handling substantial quantities of in-process plutonium. For these facilities, design loading requirements will include design basis tornado, and design basis, operating basis, and safe shutdown earthquake (seismic) parameters which will also need to be satisfied.

(c) For design of building additions, special attention needs to be given in the selection of the proper windspeed and application of wind pressures. Building additions shall be designed as if they were to be a totally new building without regard to shielding from the original building, and without regard to lesser wind resistance for which the original building may have been designed. Recognition needs to be given to the possible strengthening of the original building by the building addition.

(d) Where the Tables in ANSI A58.1 do not provide sufficient coverage, the 30 foot height (or less) coefficients q_F, q_M, and q_p should be calculated using the following formulae.

$$q_F = 0.00268V^2$$

$$q_M = 0.00246V^2$$

$$q_p = 0.00377V^2$$

Design pressures or design loads are obtained by multiplying the effective velocity pressures by the appropriate pressure coefficients. The pressure coefficients depend on the structure shape and the size and distribution of windows, doors, or other openings.

(e) Exposure "C" (in ANSI A58.1) should be used for the design of DOE buildings, except for:

1 Buildings being designed for temporary use (not more than a three-year life), and

2 Other buildings where it can be shown that the necessary permanent shielding will be provided by natural terrain (not including shielding from trees or adjacent buildings).

(3) Design drawings shall show structural material strengths, live loads, and lateral forces used in the design of all buildings, building additions, and other structures.

c. Earthquake Loads.

(1) Except where otherwise designated within these criteria, earthquake loads shall be in accordance with the applicable section of the International Conference of Building Officials' "Uniform Building Code." In the application of seismic data, the earthquake history of the locality in question shall be reviewed. The Seismic Risk Map of the United States contained in the UBC and historical data shall be examined in order to determine the probable earthquake risk. The approximate depth of overburden shall be established from available geological maps and boring data in order to determine the probable intensity range. Advice on evaluation of the probable earthquake risk may be obtained from the National Oceanographic and Atmospheric Administration (NOAA), Washington, D.C. For standard facilities refer to U.S. Army Technical Manual TM 5-809-10 or equivalent for analysis and design of buildings for seismic loadings.

(2) Use shall be made of the site-specific seismic studies and associated seismic hazard models that have been developed for DOE sites. See paragraph 9f, below.

(3) Some facilities, such as those for radioactive material handling, processing or storage, and other facilities having vital importance to DOE programs or high dollar value that would classify them as critical facilities, may require application of dynamic analysis in determining structural requirements for earthquake loading. For example, see Chapter XXI of this Order.

d. Tornado Loads.

(1) Except where otherwise designated within these criteria, tornado design characteristics shall be determined from a review of historical damage records pertinent to the locality, the recommendations of NOAA, and expert consultants in the field of tornado research and analysis. Rotational and translational velocities, pressure drop and induced missiles shall be fully considered in determining tornado loads.

(2) Use shall be made of the site-specific tornado studies and associated tornado hazard models that have been developed for DOE sites. See paragraph 9f, below.

(3) Tornado loadings shall be applied concurrently with normal design loads but not concurrently with earthquake loads or normal wind loads.

(4) Some facilities, such as those for radioactive material handling, processing or storage, and other facilities having vital importance to DOE programs or high dollar value that would classify them as

critical facilities, may require application of special tornado loading criteria. For example, see Chapter XXI of this Order.

e. Internal Shock Loads. When located near other facilities, building structures that house operations may release energies from rupture of equipment or explosions, either inadvertently or purposely (such as testing). Such structures shall be designed to sustain the resulting internal shock pressure loads.

f. Site-Specific Seismic, Straight Wind, and Tornado Characteristics. The DOE Headquarters' Office of Nuclear Safety has a program for development of site-specific natural phenomena hazard models for the principal DOE sites. These models will provide tabular and graphic displays of natural phenomena parameters (e.g., maximum straight wind/tornado wind speeds and maximum seismic ground acceleration values) at various "mean recurrence levels" (in years). After these hazard models are completed it is then planned to develop guidance for uniform selection and application of the mean recurrence levels in the planning and design of comparable types of facilities (or facilities with comparable levels of hazards/importance to DOE missions), at the various DOE sites; and in the evaluation of existing higher-hazard "critical" facilities for possible upgrading needs. The final developed data and guidance are planned to be reflected in subsequent revisions or additions to this general design criteria chapter.

10. SUBSURFACE INVESTIGATIONS.

a. For all permanent structures, subsurface conditions shall be determined by means of borings, test-pits, or other methods which adequately disclose soil and ground water conditions. Use shall be made of data and other information obtained from prior subsurface investigations at the site, supplemented by additional investigations at the specific structure location as deemed necessary. New subsurface investigations shall be made at the specific locations for all major permanent structures, and for other permanent structures at sites where no prior subsurface investigations have been made.

b. In earthquake areas, appropriate geological investigations shall be made to determine the contribution of the foundation (subsurface) to the earthquake loads imposed on the structure.

c. All subsurface investigations services shall include, but are not limited to, a recommendation of foundation type, determinations of allowable soil bearing design capacity, and the possible effects of seismic activity on the soil mass. A settlement analysis under differential design loads shall be required where differential settlement may cause structural or architectural distress.

11. BUILDING COMPONENTS.

a. Framing.

(1) In general, buildings should be structurally framed to permit simple form work, fabrication, and construction procedures. Appreciable savings are often possible through continuity in framing design; rational use of ultimate strength design and other up-to-date design and construction methods; and use of improved construction materials.

(2) Lightweight materials for floors, walls, partitions, and other building components should be utilized where consistent with programmatic/operating requirements, economy objectives, fire protection and other safety requirements, and where there are no overriding acoustical requirements.

(3) In earthquake or high wind areas, in addition to building code requirements, good engineering judgment shall be used in designing structural systems to assure that failures will not occur in critical members and joints.

b. Floors.

(1) Where site characteristics and other conditions permit, first floor construction should employ a concrete slab on well compacted earth or free draining fill. Excessive loads or equipment subject to vibration shall be supported by specially designed pads isolated from the normal floor slab with flexible joints. Framed concrete first floors over crawl spaces should be avoided. Where site contours require, foundation walls should be designed as retaining walls to support subfloor fill and floor loads in lieu of framed concrete floors.

(2) For framed floors, the economy of prefabricated systems should be evaluated, especially those systems which simplify the installation of mechanical, electrical, and communications services. Where concrete floors are used, the economy of flat plate slabs shall be investigated with the objective of utilizing their undersurface for ceilings.

c. Control Joints. When poured concrete floors, or concrete or masonry walls are used, adequate control joints and expansion joints shall be provided. In long walls, design and location of control joints shall receive careful study in order to confine the effects of the total expansion and contraction. In addition, necessary bond beams and anchors to structural framing shall be provided for masonry units; as well as flashing, bond breaks, and weep holes to minimize potential for moisture build-up and cracking due to differential movement. Manufacturers' research data and recommendations shall be investigated in order to realize optimum performance of the various materials.

d. Exterior Walls.

(1) Materials. Foundation walls should be constructed of poured concrete. The use of masonry walls below grade should be avoided, except where deemed suitable for existing site conditions and project requirements. For exposed exterior walls, consideration should be given to masonry composite walls, insulated metal or concrete panels and other prefabricated wall construction. Where the lower portion of exterior wall(s) is subject to damage from vehicle traffic, material handling or other activities, care shall be taken in selecting a proper material and material thickness, or possibly providing a protective wainscot. Exposed insulation, light metal construction, or frangible materials shall be protected from activities which could cause damage. Building facades should reflect an honest representation of building function and materials of construction. However, the relationship of new buildings to the surrounding site and to existing buildings need to be considered. Clashes between existing and new architectural styles should be avoided, but older less suitable styles of architecture should not be copied, with the possible exception of additions to existing buildings.

(2) Insulation and Vapor Barriers.

(a) Where composite walls are used, consideration shall be given to the compatibility of the insulating and facing materials. Vapor barriers and fibrous insulation shall be noncombustible or labeled by a nationally recognized testing laboratory as meeting a flame spread rating of 25 or less and a smoke developed rating of 50 or less. For cavity walls, use of treated (water repellent) granular fill may be appropriate. Rigid board insulation of cellular materials generally retain their insulating values longer than do fibrous materials that are more vulnerable to moisture. Foamed-in-place insulations should be carefully evaluated due to possible problems in shrinkage of the foam and their resistance to high temperature and humidity.

1 Where foamed plastic insulations such as urethane are used, care shall be given to effectively seal the insulation within the sandwich wall construction or panel assembly to protect against release of toxic gases under fire conditions. See Chapter X, for additional criteria.

2 Where blown-in or foamed-in-place insulating media applications are planned for hollow walls, the effects on electrical wiring within the walls needs to be evaluated and assurance given that the operating temperature of the wiring will not exceed that designated for the type of insulated conductor involved (see Article 310 of the National Electrical Code).

The potential for heat buildup in flush-mounted wall receptacles and switch boxes, or other flush mounted electrical equipment, should be also evaluated.

(b) The use of vapor barriers is encouraged, and may be integral with the insulating material. Vapor barriers should always be provided where humidity control is required, and where high humidity could cause condensation in the insulation or on the building structure or systems. In addition, vapor barriers may be an efficient way of controlling convection of hot or cold air due to wind or type of building construction.

(3) Finishes. In general, finishing of exterior walls should be kept to a minimum. Concrete walls should be left natural and unpainted unless economical finishing methods can be employed or where aesthetics and operating considerations require finish. Where color treatment of exterior walls is used, colors should be selected to harmonize with the environment and natural setting. The number of colors used for a building or complex should be limited, and carefully selected to provide a dignified public image. Colors used for painting should be selected from Federal Standard 595.

(4) Design. Walls shall be designed to resist wind, seismic, earth, blast, or other forces to which they may be subjected. If the wall is required to act as a shear wall, the wall and its connections must be specially designed. If the wall is to act as a filler or curtain wall, the connections to the structure must be capable of allowing the structure to deflect and yet maintain structural and weather-resisting integrity.

(5) Construction. Story heights and bay sizes shall be designed to accommodate coursing. Masonry walls shall be laid out in even coursing to fit between beams, columns, and standard-sized openings to minimize cutting of masonry units. Where side-hill sites require use of concrete retaining walls, such walls should be utilized as building walls, where practicable, to achieve economy in construction.

(6) Waterproofing, Damp-proofing, and Drains. The need for basements or other subgrade facilities shall be carefully evaluated in locations where ground water levels or drainage problems exist. Dense concrete with satisfactory control joints generally need not be waterproofed or damp-proofed in locations where the ground water level is significantly below the foundations. The site shall be graded to provide drainage of surface water away from the building. Masonry walls below grade shall be protected against leakage with suitable cement parging and bituminous coatings or membrane applications. Masonry walls above grade shall also be protected against moisture penetration by such means as adequately filled, compressed joints; cement coatings; lintel and sill flashing; flashing or weatherbreak offsets at spandrels; and overlapping weatherbreaks where masonry abuts columns and beams (masonry walls tend to crack and leak if the

thickness is reduced where they partially engage columns and where roof thrust may exert unequal stress). All doors and windows frames, and other sources of leakage, such as some types of control joints, shall be caulked with a durable, flexible caulking compound. Piping and other utility service penetrations shall be suitably designed to prevent leakage. Where subsoil drainage systems are provided around foundations, ground water is a problem, and drains are functionally necessary, drainage shall be conducted to a storm drainage system, not connected to the sanitary sewer system.

e. Roofs. It is recommended that roofs be sloped a minimum of 1/2 inch per foot by sloping the roof framing system. If this is not possible, the roof shall be sloped no less than 1/4 inch per foot. It is important, however, to recognize that a 1/4 inch per foot slope may often be inadequate to overcome structural short and long term deflections, construction tolerances, and variations in material thicknesses, resulting in ponding of water. Flat roofs, except for special designs, shall be avoided. Roof walkways shall be provided to mechanical equipment housings (penthouses), and to and around other roof-mounted equipment that will require routine inspection and servicing, to protect roofing materials from traffic and work-related damage. Roofs should generally be pitched to the outside perimeter for simplified drainage except where building requirements dictate otherwise. Overhangs and canopies should be considered as components of passive solar design or to otherwise provide weather protection at building entrances and loading docks. Where roof hatches are required for smoke or heat venting, they shall be designed in accordance with NFPA No. 204, "Smoke and Heat Venting." It should be recognized, however, that such vents are not effective in sprinklered buildings. Where appropriate, the building ventilation system should be arranged for smoke removal.

(1) Materials. Roof decking shall be of noncombustible materials, with the possible exception for buildings of otherwise combustible construction. A type of roof construction that will minimize the need for interior ceiling finish should be selected, unless a significant increase in the overall cost will result. Roof covering shall be of the simplest most durable type, requiring a minimum of maintenance, and consistent with the roof construction employed. Built-up roofs shall meet the specifications for bonded types. Roof coverings on metal decks shall not be capable of generating self-propagating fires on the underside of the roof deck. Insulation, vaporseals, and fastening methods shall comply with the assemblies listed as Class I by Factory Mutual. Non-conforming assemblies proposed for small buildings or fully sprinklered buildings, shall have the prior approval of the DOE fire protection authority having jurisdiction. Underwriters Laboratories Class "A" composition shingles may be used on pitched roofs with a slope of 5 in 12 or greater. Where sprayed-on, coated foam plastic roof coverings are applied to combustible or noncombustible roof decks, they shall be Underwriters Laboratories Class "A".

(2) Design. Roofs shall be designed to resist vertical live, snow, and wind loads in accordance with ANSI A58.1, but in no case less than 20 psf. The roof shall also be designed as a part of the lateral force resisting system to make the building unit(s) act as an integral system. Single sheet metal roof decking shall be a minimum thickness of 22 gauge and designed to span not more than 4 feet to limit deflection and protect the roofing from subsequent damage. Use of lightweight concrete over a metal deck should be avoided.

(3) Flashing. Copper, aluminum, galvanized steel, stainless steel, or terne-coated stainless steel shall generally be used for metal flashing and other metal work. All metal surfaces in contact with masonry materials should be painted with alkali-resistant coatings, such as heavy-bodied bituminous paint. Care shall be taken to minimize direct contact of dissimilar metals, to avoid electrolytic action. Aluminum should not be in direct contact with metals other than stainless steel or zinc coatings. Where aluminum may contact other metal surfaces, such as copper, those metals should be primed and coated with aluminum paint. Appropriate protection requirements need to be identifed in the construction specifications, and proven-acceptable flashing methods required. Treated wood nailers should be provided, bolted to the structure at the roof perimeter and around all roof penetrations to provide solid anchorage of the flashing system. Refer to the National Roofing Contractors Association, "Roofing Manual," for flashing and other details.

(4) Drainage. Where feasible, roof drains should be provided in lieu of gutters and downspouts, with a minimum pipe size of 4-inch diameter. Roof drains, gutters, and downspouts should be equipped with suitable devices to prevent obstruction by debris. Exterior downspouts subject to damage from vehicles or other outside activities shall be protected. In cold climates, gutters and downspouts should be equipped with heat strips to prevent ice blockage. The anticipated life expectancy of the structure shall be considered in the selection of metal and protective coating for gutters and downspouts. Where there is danger of soil erosion damage, storm sewers or draining ditches shall be provided to conduct roof drainage away from the buildings. Roof drainage systems shall be designed for a storm which should be exceeded only once in 10 years and an intensity, in inches per hour, lasting 5 minutes. Refer to the SMACNA "Architectural Sheet Metal Manual" for design data.

(5) Protection and Maintenance.

(a) While it is a fact that every roof will fail or wear out in time, roof life can be maximized, and roof maintenance requirements minimized, by minimizing the direct installation of rooftop equipment. Whenever possible, standard building mechanical equipment should be installed within a penthouse or within the building.

(b) Each roofing penetration is a potential source of water entry, as with penetrations of any waterproofing system. The use of roof-mounted solar collectors, and other roof-mounted equipment, on new or existing roofs can, for example, be a significant contributing factor to accelerated roof failure if not properly installed. Where direct rooftop installations of equipment are unavoidable, the supporting frames should have legs or posts of sufficient height above the roof membrane to facilitate roof maintenance, and total roof replacement without requiring equipment removal or structural support alterations. In general, the bottom of equipment stands should be at least 3 feet above the top of the finished roof membrane. For equipment setting on curbs, one foot above the finished roof should generally be adequate.

(c) The method of flashing supporting-legs or posts to the roof requires special attention. The use of improved methods, in lieu of conventional pitch pans (or pitch pockets) that have not always been satisfactory, should be investigated and the current recommendations of the National Roofing Contractors Association (NRCA) followed.

(d) Equipment placement on roofs generate other potential roof, or roof support, damage problems related to roof traffic during placement and during subsequent servicing, or replacement. In many cases, the weight of mechanical equipment or other equipment can be such as to require specific placement in accordance with the structural design loading of the roofing support system. The movement of heavy equipment across a roof will often cause structural deflection of the roof deck sufficient to break the bond of the roof, as well as cracking the felts. Crane or helicopter placement is sometimes necessary in lieu of dragging or skidding the equipment across the roof. For equipment installation and later servicing, it is necessary to provide suitable roof protection not only for personnel access to the equipment but also around the equipment, itself. Generally, the most roof damage can result from work efforts in the immediate equipment area.

(e) An effective roof management and maintenance program is an important element of the overall facility or site maintenance program. Integral to the program is a system of control that not only limits building roof access to authorized personnel but also provides a mechanism for review and approval of proposed additions of roof mounted equipment. This review of equipment additions should include an analysis of the building structure, placement method, roof protection provided, and flashing provisions.

f. Thermal Transmittance Values. Thermal transmittance values to be utilized in building design for energy conservation, for exterior walls floors above unheated spaces, and roofs, are contained in Chapter XIII of this Order.

g. Interior Walls and Partitions.

(1) Materials. Interior walls and partitions may be of materials with characteristics similar to those used for exterior walls or of prefabricated, fire-resistant or noncombustible, competitive-type partitioning. Fire-retardant treated wood or other inhibited material should be permitted only where more fire resistant or noncombustible materials cannot be used, and as approved by the DOE fire protection authority having jurisdiction. Wood stud walls with economical finish may be used in buildings of otherwise combustible construction. Metal mesh enclosures shall be used wherever they are suitable. Firewalls must necessarily be of materials which will develop the requisite fire rating. Where tile surfaces or equivalent may be required for functional reasons, structural facing units instead of applied finish shall be used if economy can be realized.

(2) Movable Partitions. Movable partitions shall be used in areas of buildings where a need for periodic rearrangement of space is a known requirement, and should be noncombustible. They shall not be used in place of fixed partitions for corridors and permanently assigned space except where the quantity of such fixed partitions is small compared to the total required. Movable partition layouts shall take full advantage of modular bay arrangement, columns, and dropped beams. When full-height movable partitions are used, floor and ceiling finishes shall be applied before partitions are erected. Post and panel types of movable partitions shall be specified whenever feasible rather than the more costly flush types, insulated types, and glazed types. Use of metal panel partitions should be limited in favor of less costly materials. When used, metal panels should be of a single thickness material where noise transmission or other operational factors permit. Wall linings to match movable partitions should not be provided. Use of dwarf partitions shall be considered in large office spaces.

h. Ceilings.

(1) Ceiling Heights. Ceiling heights in all buildings shall be held to the minimum consistent with operating requirements. Where the use of suspended ceilings is justified, floor-to-floor heights and space above suspended ceilings shall be held to the minimum required to

accommodate mechanical and other systems. Ceiling heights, to the underside of joist or panel construction or to the underside of suspended ceilings, should generally not exceed the following:

Space	Height
Administrative	8'6" to 9'6"
Standard Laboratory	9'0" to 10'0"
Cafeteria	11'0"
Others	Minimum consistent with operating requirements.

(2) Finishes. In shops, warehouses, and other industrial-type buildings, the basic structure should be left exposed with no ceiling finish except where justified to facilitate heating, ventilation, sanitation; reduction of excessive noise levels in specialized areas; or to isolate contaminated areas. Economically competitive, suspended ceiling systems may be provided in administration and laboratory buildings where such installations will result in economy in heating and cooling, are necessary to provide acceptable noise levels, or are required to minimize dispersion of contaminants and provide acceptable levels of cleanliness. Roof and overhead floor construction should be designed to avoid the need for ceiling finish other than painting or applied acoustical surfaces.

i. Interior Finishes. Economy in finishes shall be achieved based upon life cycle cost principles. Interior finishes shall be in keeping with the character of the building. For example, areas in industrial-type buildings shall receive less costly treatment than comparable areas in administrative buildings. See paragraph 5d(2) in Chapter X, for additional interior finish criteria. In the selection of interior colors, a coordinated color scheme should be developed by the architect or qualified consultant during the project design. Paint colors should be selected from Federal Standard 595, and the number of colors held to a practical minimum. In areas where radioactive materials are being processed or handled, cleanable surfaces shall be provided through the use of washable or strippable coatings, metal linings, and so forth. Areawide requirements can, in some instances, be minimized by the use of separate enclosures around radioactive work spaces.

j. Interior Floor Coverings. Where interior floor coverings are used they shall conform to the criteria in Chapter X.

k. Acoustical Treatment.

(1) The services of qualified persons in acoustic design should be utilized, particularly for areas, with high sound pressure levels, and for such other areas as large conference rooms, data

processing centers, word processing centers, auditoriums, audio/video studios, program control centers, and secure rooms.

(2) In general, for industrial-type facilities, or other high sound-level facilities, the principal objectives are to achieve an acoustic environment that is noninjurious to the occupants, and conducive to work performance and safety in operations. For nonindustrial-type facilities, with lower sound levels, the principal objective is to achieve a balanced acoustic environment for the occupants and functions to be performed.

(3) Acoustical treatment should not be provided in storage areas or other service and support areas.

(4) Utility rooms (mechanical/electrical equipment rooms), or other areas where operating equipment is located, should be given special consideration. While such areas may not be normally occupied, high sound levels often exist that can be injurious to operating/maintenance personnel, even with short-duration exposure. Where acoustic treatment is not feasible, or would not be adequate, anticipated noise levels and requirements for personal protective equipment (and/or the need for administrative control to limit employee exposure to safe duration periods) should be identified in advance of equipment operation. For reference see 29 CFR Part 1910, "Occupational Safety and Health Standards," Subpart G, 1910.95, "Occupational Noise Exposure."

(5) Acoustical materials shall conform to the criteria in Chapter X.

l. Windows and Doors. Windows and doors shall be of stock sizes and competitive design. The more economical industrial and energy efficient types shall be used whenever practicable. Doors and windows shall be selected to fit masonry coursing and structural members. Provisions for the escape of heat and smoke in the event of fire shall be considered in the design of windowless buildings.

(1) Fenestration. Except where greater use of windows or other forms of glazing is justified (based on building energy use analysis and life cycle cost effectiveness), fenestration should be kept to the minimum necessary to satisfy basic functional and operating needs. In the selection of fenestration methods and materials, careful consideration shall be given to the requirements for building energy use reductions in new DOE facilities, as covered in Chapter XIII of this Order.

(a) It is important to recognize that heat loss ranges by a factor of about 30 between well-insulated walls and windows, for single glazing. Significant improvements can be made by the use of double or triple glazing. For example, double glazing will reduce heat loss by about 50 percent, with only a 10-20 percent reduction in solar heat gain. Triple glazing will further reduce heat loss by an additional 1/3, with an additional 10-20 percent reduction in solar heat gain.

(b) All glazed areas shall be carefully planned. Generally, major fenestration should be limited to the south facade of the building and/or in overhead locations where "atrium" or "skylight" concepts can be effectively used as an element of the overall energy-efficient building design. For the windows that are to be provided, and particularly those to be located in other than the south facade of the building, insulating types shall be used where the heating degree-days exceed 3,000, and should be considered for use in lower heating degree-day locations. Where the heating degree-days exceed 6,000 triple-glazed windows or equivalent having an R value of at least 3 per manufacturer/testing guarantee, should be used. Consideration should be given, in above 6,000 degree-day locations, to the use of thermal-break window frames.

(2) Doors and Frames. Fire doors shall conform to Underwriters Laboratories (UL) or Factory Mutual specifications and be properly labeled. Installation shall conform to NFPA No. 80, "Fire Doors and Windows." Vestibules, preferably of the recessed type, may be provided for exterior doors. Double-acting doors and regularly-used egress doors shall be provided with vision panels. Automatic closers may be used where functionally necessary. Safety glass shall be provided in full length glass doors.

(3) Hardware. All builders hardware shall be suitable for the required functions and shall be utilitarian and competitive. Hardware shall be of durable grade consistent with the life expectancy of the building and appropriate Federal specifications. New items of hardware should be located to be accessible for handicapped persons, while still convenient for other personnel use. The use of floor mounted door checks or closers should be avoided. Exit and fire door hardware shall conform to UL specifications.

m. Radiation Shielding. Although conventional concrete can be the most economical shielding material, such factors as space limitations sometimes require the use of high density, or heavy concrete (see ANSI Standard N101.6, "Concrete Radiation Shields"). Since the attenuation of neutrons, gamma rays, and proton particles is approximately directly proportional to the density of the shielding material, various heavy aggregates have been utilized in the manufacture of heavy concrete. Naturally occurring aggregate materials, such as magnetite, ilmenite, limonite, and barite, should be used. Iron and steel scrap have also proven to be satisfactory aggregates, but normally cost considerably more than the naturally occuring ores. Suitable materials in close proximity to the project are usually the most economical since transportation is a large component of aggregate cost. Densities in the range of 200 to

400 lbs./cu. ft. have been obtained through the use of various heavy aggregates. Portland cement has produced more satisfactory results than have other cementitious materials. Placement by either conventional or preplaced aggregate methods has proved to be acceptable. Vigilant field control and proper proportioning, mixing, placing, and curing shall be specified to assure a satisfactory product.

12. FIRE PROTECTION. General design criteria for fire protection are contained in Chapter X. Additional criteria for specific types of facilities are contained in other chapters, beginning with Chapter XVI.

13. FACILITY DESIGN FOR THE PHYSICALLY HANDICAPPED. It is particularly important that full consideration be given to the needs of physically handicapped persons in planning for new facilities and site development. Necessary features must be incorporated in follow-on design/construction to assure barrier-free access, egress, and use by the handicapped. In determining the applicability of Federal statute and implementing Federal regulation requirements to specific projects (see paragraph 3, subparagraph o, in Chapter I) it is important that the term "physically handicapped" be properly understood.

   a. Physically handicapped encompasses not only non-ambulatory and semi-ambulatory disabilities but the broader range of sight, hearing, and coordination impairments, in addition to manifestations of the aging process. In this proper context. "barrier-free" design/construction can have wide employee and public benefit and does not narrowly relate to providing "special accomodations" for a "select few", as it may often be interpreted. It is also important to recognize that provision of many of the required features will result in improved convenience and safety for non-handicapped persons. Some examples are: access/egress ramps instead of steps; hand rails; elimination of steps in walks; nonslip floor surfaces; elevator, cab control and alarm features; audible/visual warning signals; and height requirements for door closers, hanging signs, lights and other fixtures.

   b. Each planned project shall be carefully examined for applicability of the standards prescribed in the Federal Property Management Regulations (FPMR) Subpart 101-19.6. Unless there are overriding and justifiable reasons for not meeting these requirements, they shall be satisfied.

   c. Design decisions shall be documented for each project in accordance with FPMR Subpart 101-19.606, and shall be addressed in each design report or other design documentation, as appropriate for the particular project. It is important that these decisions be made in the project planning phase, or prior to full project authorization at the latest, to assure that the capital costs for providing the necessary features are properly included in the overall project cost estimate.

14. ELEVATORS.

   a. Elevators shall conform to the latest version of ANSI A17.1, "Safety Code for Elevators, Dumbwaiters, Escalators, and Moving Walks." At least one elevator in each bank of elevators shall be equipped so that firefighters and other emergency personnel can manually control it. Hydraulic-type elevators should be considered for buildings of five stories, or less. The number of passenger elevators, size and capacity, location, types of machinery, and controls shall be determined by careful study, utilizing the services of a qualified elevator consultant and taking into consideration the building population, building layout, and traffic flow patterns. Freight or service elevators shall be located in proximity to loading docks, shipping and receiving areas, and storage areas. Combination service-passenger type elevators may be appropriate for buildings of less than three stories for movement of equipment, furniture, and limited use by personnel.

b. With the possible exception of some of the smaller, 2-level or 3-level, buildings or building additions as described in paragraph d, below, passenger elevators shall be provided in all occupied multi-level buildings. Passenger elevators shall also be provided in all occupied multi-level building additions where existing building capacity is inadequate or is inaccessible to additional occupants.

c. Whenever new multi-level buildings or building additions are required to be accessible and usable by physically handicapped persons (i.e., accessible to the general public, opportunities for employment therein of handicapped persons and/or satisfaction of DOE affirmative action requirements for nondescrimination in Federal (DOE) employment), passenger elevators shall conform to "The Suggested Minimum Passenger Elevator Requirements for the Handicapped," of the National Elevator Institute, Inc., in addition to ANSI A17.1.

d. It is recognized that the cost for passenger elevators can be a significant portion of the total project cost for the smaller, 2-level or 3-level, buildings and building additions. For the smaller facilities where accessibility and usability by physically handicapped persons will be required, consideration may be given to the provision of adequate ramps or perhaps, the provision of wheelchair lifts in lieu of passenger elevators, where such alternate methods may be feasible. If wheelchair lifts (platform lifts) are provided, they shall be fully-enclosed, capable of safely and comfortably transporting an occupied wheelchair, and be fully operable by the occupant without assistance. For those smaller facilities that will not be accessible to the general public and no opportunities for employment of handicapped persons therein passenger elevators should not be provided, unless specifically justified.

15. PERSONNEL SHELTERS. Section 3002, subsection (4), of Executive Order 11490, "Assigning Emergency Preparedness Functions to Federal Departments and Agencies," requires federally constructed buildings to protect the public to the maximum extent feasible against the hazards that could result from a nuclear weapon attack on the United States.

a. When feasible, fallout shelter provisions shall be made in the design of new DOE facilities in accordance with Federal Emergency Management Agency (FEMA) "Standards for Fallout Shelters," TR-87 (latest edition).

b. Fallout shelters should be in dual purpose space, such as space which accommodates day-to-day building operations of such nature that furniture and equipment not needed for shelter purposes can be moved for fallout shelter occupancy. Included among possible shelter space, could be interior corridors, interior rooms, or belowground space, where such locations are satisfactorily shielded to provide a minimum protection factor of 40. As defined in FEMA/TR-87, of 9-79, "Protection Factor", is a numerical value which expresses the relation between the amount of fallout radiation that would be received in a protected location and the amount that would be received if unprotected in the same location." "Slanting" design techniques shall be used insofar as practicable. Slanting may be defined as "the incorporation, with little or no extra cost or reduction in efficiency, of certain architectural and engineering features to protect personnel from fallout gamma radiation."

c. It is important when obtaining architect-engineer services for design of buildings that are to have fallout shelter provisions, to assure that the selected firm has the required technical competence in radiation shielding technology, including fallout shelter analysis capability.

d. There will be instances where it will not be feasible to make fallout shelter provisions in new DOE facilities. See the instructions for preparation of construction project data sheets in the DOE Budget Manual, as specifically related to fallout shelters.

METHOD OF COMPUTING BUILDING AREAS AND VOLUMES

1. GROSS AREA. The gross area of each floor in the building shall be measured from outside to outside of the enclosing walls. The total gross area of a building is the sum of all gross floor areas, including service floors, basement space, enclosed appendages and penthouses. Areas of open loading platforms whether roofed or uncovered shall be tabulated separately and not included in the total gross area.

2. NET USABLE AREA. The usable area of a building is comparable to the rentable area of commercial buildings and comprises space occupied by or assigned to functional purposes other than building services. It includes that portion of shipping and receiving space required for the daily operation of any of the functional activities. Areas to be excluded in computing "Net Usable Area" include exterior walls, firewalls, lobbies, corridors, stairs, elevators, pipe and duct spaces, janitors' closets, custodial locker and maintenance rooms, mechanical equipment space for building operation equipment, fan lofts, unassigned storage or open areas, toilet rooms, that portion of shipping and receiving space which is required for building services. Auditoriums, garages, and specialized areas shall be considered as usable space, they shall not be included in computing the net usable area per person but may be used in determining an overall efficiency ratio. Net areas shall be measured from the interior face of exterior walls and faces of masonry firewalls to the center-lines of partitions.

3. GROSS VOLUME. The gross volume of a building is the actual volume enclosed within the outer surfaces of the outside walls and between the outer surfaces of the roof and the underside of the lowest floor slabs or to grade where crawl spaces occur and includes:

   a. Basement space, finished or unfinished, whether floored or not if, the space is usable;

   b. Special subgrade structures which are a part of such facilities as reactors, particle accelerators, or other R&D facilities, including footings, pits, trenches, and other necessary features of substantial volume. For these special structures, the cubic content of construction below the bottom of the adjacent floor slab shall be shown separately;

   c. Projections beyond the normal building line, such as entrances, platforms, chimneys, and air intakes. Volumes of unenclosed loading platforms and roofed entrances shall be computed separately but not included in the gross volume; and

   d. Superimposed structures above the roof surface, such as fan lofts, elevator and stair penthouses, etc. The gross volume shall not include canopies, cornices, pipes, vents, or ducts exposed above the roof surface, or footings, foundation walls, pits, trenches, and other depressions below floor slab or finished grade except where part of special facilities, such as reactors, particle accelerators, etc.

CHAPTER V

MECHANICAL SYSTEMS

1. COVERAGE. These criteria shall be applied in the planning and design of mechanical components of facilities. Included are heating, adiabatic cooling, ventilating, and airconditioning systems for general service and allied facilities; incineration; and water and sanitary systems. Additional mechanical systems criteria for specific applications are contained in other chapters, beginning with Chapter XVI of this Order. Criteria applicable to air and water pollution control are contained in Chapters XI and XII.

2. CODES, STANDARDS, AND GUIDES. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE) Handbooks, and the National Standard Plumbing Code (cosponsored by National Association of Plumbing-Heating-Cooling Contractors and American Society of Plumbing Engineers), as a minimum, shall be followed as the basic reference for design, except where modified by these criteria. The latest editions of the codes, standards, and guides listed below shall also be followed:

   a. Codes.

      (1) American National Standards Institute (ANSI)--Code Requirements.

      (2) American Society of Mechanical Engineers (ASME)--Boiler and Pressure Vessel Code Requirements.

      (3) National Fire Protection Association (NFPA), National Fire Codes.

   b. Standards.

      (1) Associated Air Balance Council (AABC).

      (2) American Boiler Manufacturers Association (ABMA).

      (3) Air Moving and Conditioning Association (AMCA).

      (4) American National Standards Institute (ANSI).

      (5) Air-Conditioning and Refrigeration Institute (ARI).

      (6) ASHRAE Standard 90A-1980, "Energy Conservation in New Building Design," and Standard 62-1981, "Ventilation for Acceptable Indoor Air Quality."

      (7) American Water Works Association (AWWA).

(8) Construction Specifications Institute (CSI).

(9) Cooling Tower Institute (CTI).

(10) Hydronics Institute (HI).

(11) Institute of Boiler and Radiator Manufacturers (IBR), superseded by Hydronics Institute.

(12) Mechanical Contractors Association of America (MCAA)--Testing and Rating Code for Boiler-Burner Units.

(13) National Environmental Balancing Bureau (NEBB).

(14) National Electric Manufacturers Association (NEMA).

(15) National Fire Protection Association (NFPA) Standard 90A, "Air Conditioning and Ventilation Systems," and Standard 82, "Incinerators, Waste and Linen Handling Systems and Equipment."

(16) Steel Boiler Institute (SBI), Division of IBR, Hydronics Institute.

(17) Sheetmetal and Air Conditioning Contractors National Association, Inc., (SMACNA).

(18) Underwriters' Laboratories, Inc. (UL).

c. Guides.

(1) Air Force Manual (AFM) 88-8, Chapter 6, "Engineering Weather Data."

(2) American Conference of Government Industrial Hygienists "Industrial Ventilation Manual."

(3) General Services Administration/Public Buildings Service (GSA/PBS) Publication, "Energy Conservation Design Guidelines for New Office Buildings."

(4) GSA/PBS Publication, "Energy Conservation Guidelines for Existing Office Buildings."

(5) Federal Construction Council (FCC) Technical Report No. 51, "Combustion Equipment and Related Facilities for Nonresidential Heating Boilers."

(6) Federal Construction Council (FCC), "Federal Construction Guide Specifications."

(7) Oak Ridge National Laboratory (ORNL) Nuclear Air-Cleaning Handbook, "The Design, Construction, and Testing of High-Efficiency Air-Cleaning Systems for Nuclear Application," ERDA 76-21 (ORNL-NSIC-65-1).

(8) Thermal Insulation Manufacturers Association (TIMA), "Economic Thickness Manual."

(9) Environmental Protection Agency (EPA) Publication No. SW13TS, "Municipal Scale Incinerator Design and Operation Manual."

3. PLANNING. Project planning and preliminary design analyses used in the selection and sizing of mechanical systems shall be energy conservation oriented. Environmental pollution control and abatement requirements shall also be addressed and shall comply with the requirements in Chapter XI and Chapter XII of this Order.

4. ENERGY CONSERVATION DESIGN. General design criteria in this Chapter are energy conservation oriented. They reflect the level of performance necessary to comply with Federal Property Management Regulation (FPMR), 41 CFR, Chapter 101, Subchapter D, Section 101-20.116, "Conservation of Energy by Executive Agencies," in the operation of DOE buildings. Basic criteria for energy conservation and use of renewable energy resources are contained in Chapter XIII, and shall be applied together with these Mechanical Systems criteria in planning and design.

5. SPECIFICATIONS.

a. When possible, equipment specifications shall be written around standard commercially available equipment and shall permit a reasonable range of competition. At least three manufacturers' equipment shall be checked for compliance with the design requirements and to assure that adequate space is available for operation and maintenance requirements. Energy-efficient equipment shall be a prime consideration as discussed in the ASHRAE Standard 90A-1980 section on heating, ventilating and air-conditioning (HVAC) equipment.

b. Specially designed equipment which is not a standard product of a recognized manufacturer, or not a competitive item, shall be avoided unless specifically justified (see DOE Procurement Regulations, DOE/PR-0028, Subpart 9-1.307, "Purchase Descriptions"). Major equipment, i.e., boilers, chillers, cooling towers, and so forth, shall be a standard product of manufacturers with a satisfactory commercial/industrial operational experience for not less than 6,000 equipment operating hours prior to bid opening. Partial load efficiencies are a major consideration and shall be used in evaluating equipment performance.

c. All air-conditioning equipment shall conform to applicable Air-Conditioning and Refrigeration Institute (ARI) Standards as a minimum requirement.

6. SYSTEMS. Selection of the building environmental systems (heating, evaporative cooling-mechanical ventilation, mechanical ventilation, and mechanical refrigeration) shall be based on an evaluation of the initial costs, operating costs, and environmental requirements. Annual owning and operating costs (life cycle costing) shall be evaluated as discussed in Chapter XIII. Consideration shall be given to projected yearly electric power and water costs, load factors, local codes, current equipment developments, and equipment obsolescence. For personnel comfort, the combination heating and cooling system is normally the most economical system, as compared to separate heating and cooling systems. Additional guidance, relating to systems type, design, and applications, is provided in ASHRAE Handbooks.

a. Installed Capacities. The initial installed heating, ventilating, and air-conditioning system capacity for buildings designed for future growth shall be limited to 120 percent of peak design load unless additional capacity is required for operational reliability. For most buildings, the installed system capacity should be equal to the system peak design load. Auxiliary-tank thermal storage shall be considered to reduce peak demand loads and to conserve energy. Oversizing mechanical equipment reduces the system operational efficiency and is inconsistent with the energy conservation objectives to operate mechanical systems at peak efficiency.

b. Reheat. Use of reheat with fossil-fuel derived energy for personnel comfort during the cooling cycle, to satisfy either temperature or humidity control should be avoided. Variable air-volume, medium-pressure systems are acceptable reheat-type systems, and may be used when economically justified.

c. Hot Water Heating Systems.

(1) In the planning and design of new or existing hot water space heating or other hot water systems for new buildings and building additions, compatibility of these systems for use of low-temperature solar-heated water shall be considered. As stated in paragraph 8a in Chapter XIII, "The application of active solar systems shall be evaluated for all building and building addition projects; and building alteration projects, as appropriate." Chapter XIII contains additional criteria, including the recommendation that consideration be given to including provisions for minimizing future retrofit costs for later adaptation of active solar systems when they may become life cycle cost effective. It is recognized that active solar systems have generally not been justified on the basis of life cycle cost analyses. However, projected increases in the costs of nonrenewable energy provide a positive and increasing incentive to plan for future application of active solar hot water systems. In the evaluation of hot water

system alternatives where the use of either high- or low-temperature hot water systems is determined to be feasible, consideration should be given to the potential benefits associated with future application of solar hot water systems.

(2) Similar considerations should be given, and evaluations performed, in deciding between the direct use of steam or conversion from steam to a low-temperature hot water supply system for space heating.

d. Adiabatic or Evaporative Cooling. Adiabatic or evaporative cooling systems shall be considered for personnel comfort cooling where the outside dry bulb temperature during the 6 warmest months is 93°F and higher for an average of 155 or more hours per year, using 3 of 5 consecutive years, and the wet bulb temperature is 73°F and higher for an average of less than 160 hours per year during the 6 warmest months and during the same 3 years. Typical applications would include warehouses, shops not requiring close (plus or minus 5°F) temperature control, kitchens, and mechanical equipment spaces. Use of these adiabatic type cooling systems in corrosive-sensitive environments shall be carefully analyzed in order to maintain an acceptable relative humidity level in the space.

e. Ventilation Systems. Natural or mechanical ventilation systems should be utilized for industrial-type structures, warehouses, garages, and dwellings. Mechanical ventilation systems may satisfy personnel comfort cooling applications for locations where the outside air temperature is 80°F and higher for less than 350 hours during the 6 warmest months of the year as listed in Air Force Manual (AFM) 88-8, Chapter 6, "Engineering Weather Data." The total quantity of air supplied to the space for personnel comfort normally should limit the ventilation air temperature rise in the conditioned space to 5-15°F depending upon the application.

f. Weather Data. Weather data may be obtained from the local weather station or reference can be made to Air Force Manual 88-8, Chapter 6, "Engineering Weather Data" (available through the U.S. Government Printing Office, Washington, D.C. 20402); the ASHRAE Handbook of Fundamentals; or by request to the National Oceanic and Atmospheric Administration (NOAA), Environmental Data Service, National Climatic Center, Federal Building, Asheville, NC, 28801.

g. Energy Management Systems and Devices.

(1) In the planning and design of mechanical systems for new buildings surveys of energy conservation retrofit opportunities, compatibility of energy management systems and devices, and potential benefits from their use shall be considered.

(2) Energy management systems and devices are more fully discussed in Chapter XIII, paragraph 12, of this Order.

7. HEATING, EVAPORATIVE COOLING, MECHANICAL VENTILATION, AND AIR-CONDITIONING SYSTEMS DESIGN CONDITIONS.

a. Design Basis. General design guidance and load estimating procedures shall be based on data in the ASHRAE Handbook of Fundamentals, Systems, Applications, and Equipment Volumes. Alternate design heating and cooling load estimating procedures may be used with the approval of the DOE field organization responsible for facility planning and design). Both peak and partial (i.e., 75 percent, 50 percent, 25 percent) load calculations shall be prepared in order to analyze system operation and to determine proper equipment performance during these various operating modes.

b. Building Envelope Thermal Transmittance Factors. See Chapter XIII for criteria to be applied in building planning and design.

c. Inside Design Temperatures and Humidities.

(1) Environmental design temperatures and humidities shall be as required for manufacturing, processing, electronic equipment, laboratories, and other "noncomfort" applications to maintain an acceptable operating environment.

(2) For personnel comfort applications, the following environmental design conditions shall apply.

(a) Cooling.

1 The inside design temperature for summer personnel comfort shall be 15°F less than the 2-1/2 percent outside dry bulb (db) weather condition as given in the ASHRAE Handbook of Fundamentals, but shall not be less than 76°Fdb or more than 80°Fdb unless otherwise indicated. The minimum design relative humidity shall be 55 percent or the relative humidity corresponding to the inside design dry bulb temperature and the outside air design dewpoint temperature, whichever is less. Summer humidification shall not be provided for personnel comfort.

2 See paragraph 12d, below, for design conditions applicable to adiabatic cooling systems.

(b) Heating.

1 The inside design temperature for winter personnel comfort shall be 72°Fdb unless otherwise indicated. Lower design temperatures may be appropriate for the particular application. The following applications indicate the range of acceptable temperatures.

Space	°Fdb
Storage (heated)	50°
Warehouses	55°
Kitchens	65°
Laundries	65°
Shops (high work activity)	65°
Toilets	68°
Change Rooms (heating only when occupied)	75°

2 Except where it can be substantiated from recordings or engineering computations that the inside relative humidity will be less than 20 percent for prolonged periods of time, such as to be detrimental to personnel health, winter humidification for personnel comfort shall not be provided. Where such conditions have been substantiated, a design relative humidity of 20 percent may be used in establishing humidification equipment requirements.

d. Outside Design Temperatures. Design temperatures shall be as shown below for the particular application as determined from the tabulated weather data in the ASHRAE Handbook of Fundamentals. 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 elevations and other local conditions affecting design data.

Application	Winter	Summer
Industrial, process, laboratory and other nonpersonnel comfort systems	99%db	1%db 1%wb
Personnel comfort systems	97-1/2%db	2-1/2%db 5%wb
Cooling Towers*-		
Research, technical-type systems		1%wb
Personnel comfort systems		2-1/2%wb

*Temperature should be verified by actual site conditions.

Application	Winter	Summer
Air-Cooled Condensers* (non-personnel comfort systems)		1%db plus 5°F
Personnel comfort systems		1%db

*Temperature should be verified by actual site conditions.

e. Personnel Ventilation Air.

(1) The outside air ventilation rate shall be at least 5 cfm/person in conditioned offices and other occupied spaces, as recommended in ASHRAE Standard 62-1981, "Ventilation for Acceptable Indoor Air Quality." Refer to ASHRAE Standard 62-1981 for this and other design data and information. Additional outside air may be required for central air handling systems to balance the system exhaust air rate, in order to maintain a building or space under a slight positive pressure (0.05 inch water static pressure).

(2) Special attention shall be given to spaces where smoking will be permitted. For these spaces, an outside air ventilation rate of 20 cfm/person should be provided. However, this rate, or higher outside air ventilation rates for other spaces, can be reduced toward the 5 cfm/person minimum required rate by properly cleaning recirculated air. Occupational health of facility occupants needs to be a paramount consideration. Design decisions, trading off recirculation and outside air ventilation, should include considerations of energy conservation and life cycle cost implications in conjunction with the applicability of non cross-contaminating heat recovery techniques.

f. Equipment. Refrigeration equipment and associated air handling equipment design, fabrication, installation, and testing shall conform to the applicable ANSI, ASHRAE, and ARI Standards.

g. Communication, Electronic, and Computer Room Design Heat Loads. The principal heat load in these types of equipment rooms is due to the installed equipment. The functional requirements are subject to growth, with additional equipment provided to meet expanding needs. In order to provide environmental system flexibility, initial equipment heat loads should be increased by at least 25 percent, or to satisfy a 5-year growth forecast, whichever is greater, in sizing the systems.

h. Operating Temperatures. The temperatures to be used for the building energy consumption analysis (see Chapter XIII) shall conform to the Federal Property Management Regulations (FPMR), 41 CFR, Chapter 101, Subchapter D, Section 101-20.116, unless otherwise justified.

8. AIR-CONDITIONING EQUIPMENT.

a. Refrigeration Equipment

(1) As general guidance, for systems of greater than 130 tons, centrifugal, absorption, or helical rotary-screw type units are normally used. Below 130 tons the reciprocating compressor type units are normally used. All refrigeration systems greater than 130 tons shall require an economic system analysis to determine the most economical total refrigeration system for the life of the

facility. The economic analysis shall include equipment first cost, replacement costs, and operating and maintenance costs. In order to accurately determine annual energy consumption, the equipment part-load energy usages and operating time shall be evaluated.

(2) Where high-pressure steam (greater than 125 psg) is available, the steam turbine-driven chiller unit and the double-effect absorption chiller unit should be considered because of the high coefficient of performance (output to input) for these type units and because of the reduction in electrical load demand charges. Operating and maintenance costs may need to be given special attention in such considerations.

(3) Where continued operation of equipment will be required during periods of electric power interruption, consideration shall be given to nonelectric driver equipment in order to reduce the emergency electric power requirements. Nonelectric drives include the gas/oil engine and steam/hot water powered chiller units.

(4) Refrigeration systems that operate year-around shall be evaluated using the following design concepts in order to maintain peak equipment operating efficiencies (Btuh output/kWH input):

(a) Allow condenser water temperature to drop with cooler outside air temperature in order to reduce equipment power demand.

(b) Operate centrifugal chillers in the "free cooling" cycle where the outside design conditions permit. When cooling demand exceeds the "free cooling" capacity of the chiller being considered or where the chiller cannot act as a thermal siphon, and when outside design conditions permit, the use of a water/air heat exchanger for obtaining chilled water should be considered.

(c) Use combination chiller-pump arrangements in order to prevent return chilled water from passing through an inoperative chiller. Ideally, the chiller-pump operation should match the system cooling demand load.

(d) Consider series versus parallel chiller arrangements in order to determine the best system operating efficiency (Btuh output/kWH input).

(5) The following ARI Standards shall be used in the selection of refrigeration equipment: ARI Standard 520, "Positive Displacement Refrigerant Compressor and Condensing Units"; ARI Standard 550, "Centrifugal Water-Chilling Packages"; and ARI Standard 590, "Reciprocating Water-Chilling Packages."

(6) Sound-level measurement within equipment rooms shall follow the procedure outlined in ARI Standard 575, "Method of Measuring Machinery Sound Within Equipment Rooms."

(7) Central chilled water plants shall be considered where two or more adjacent buildings are to be air-conditioned. The use of multiple independent systems is generally discouraged because of higher operating and maintenance costs. The number and size of refrigeration units shall be based, in part, on the annual estimated partial-load operation of the plant to assure the most economical operation.

(8) Underground chilled water piping to multiple building systems shall be designed to achieve the least annual owning and operating cost. Factors to be considered are: future expansion, supply-return water temperature differential (14^{o}F to 16^{o}F, minimum), reasonable water velocity to reduce erosion and pump horsepower (4 to 7 fps recommended), and system diversity factor to reflect actual demand (0.80 factor is generally applicable).

b. <u>Air-Cooled Condensers.</u>

(1) For all refrigeration compressor installations, the use of air-cooled condensers shall be evaluated where commercially available. Economic system analyses for selecting either air or water condensing equipment shall be based on the annual owning and operating costs (energy, maintenance, necessary water treatment, and equipment replacement) for the air-conditioning system life.

(2) Refrigerant head-pressure control shall be provided to maintain satisfactory compressor operation during light loads, as recommended by the manufacturer. For comfort cooling installations, head-pressure control is generally provided for partial load operation where the system operating temperature difference is twice the design temperature difference (refrigerant condensing temperature minus outside design temperature).

(3) For noncomfort cooling installations requiring refrigerant head-pressure control, multiple fan units are recommended for installation with selective air volume control dampers or variable fan speed.

(4) Air-cooled condensers should not be located where the sun's rays shine on the condenser during peak cooling load periods. Sun screens shall be considered for use when condensers cannot be installed in suitable locations.

c. <u>Cooling Towers.</u>

(1) Mechanical draft water cooling towers are normally used for refrigerant units in excess of 100 tons. Package water treatment

equipment shall be provided, as required, to maintain the condenser water within acceptable limits of scale formation, corrosion, and organic growth. An automatic-controlled water bleed is required for all cooling towers. In determining the necessary water treatment program, a qualified corrosion engineer shall be consulted. Cooling tower life may be prolonged through:

(a) The chemical treatment of tower members to form a coating over the wood that is insoluble in water.

(b) The pressure treatment of the wood with chemicals that are toxic to the organisms which cause wood decay.

(c) The use of noncorroding ceramic, plastic, and metal components instead of wood.

(d) Neoprene-fiberglass fill.

(2) Cooling towers that operate year-around shall have automatic condenser water temperature control to maintain an optimum refrigeration equipment operating efficiency. Generally, the minimum acceptable control includes a low limit aquastat in the water sump to sequence fans on low temperature setting and a condenser water flow control valve. Where freezing outside air temperatures occur, artificially induced thermal heat should not be used until alternate nonenergy consuming solutions have been considered, i.e., remote interior sump in a heated enclosure.

(3) Verification of cooling tower performance is important since the condenser supply water temperature directly affects the refrigeration equipment performance which, in turn, affects the air handling system performance. Cooling tower acceptance tests should be required where the cooling tower system is complex, not a standard product of a recognized manufacturer, and/or if the cooling tower is larger than 350 tons design capacity. Such acceptance tests shall be conducted by an independent testing firm (not the construction contractor), in accordance with the procedures described in Cooling Tower Institute Bulletin ATP-105, "Acceptance Test Procedure for Industrial Water-Cooling Towers."

(4) Combustible cooling towers shall comply with the fire protection standards of NFPA No. 214. Instead of installing a fixed fire suppression system, consider installing a cooling tower with noncombustible fill, eliminators, exterior walls, and top.

(5) Once-through cooling for condensing purposes may be considered instead of cooling towers where: available water is of sufficient supply for the intended system life, water treatment requirement is

minimal, system is justified on a life-cycle costing basis, and most importantly, the spent water can be returned to its natural environment or stratum where initially taken.

d. Water Treatment.

(1) The available water supply shall be evaluated, and samples analyzed, to determine its chemical composition and physical characteristics (temperature and quantity) in order to prescribe necessary treatment for the intended purpose.

(2) Treatment and deaeration of boiler water shall be provided where necessary to reduce scale formation, corrosion, and foaming. A continuous blowdown system shall be investigated to reduce concentration of solids in boilers and similar large heating or process steam units.

(3) Cooling tower and boiler blowdown system discharges shall be piped to the sanitary or industrial drain system, as appropriate; and pretreated as required to reduce environmental pollution, in accordance with pollution abatement principles and applicable Federal statute, Executive order and regulation requirements identified in Chapter XII, "Prevention, Control, and Abatement of Environmental Pollution," of DOE 5480.1A; and Chapter XII, "Water Pollution Control," of this Order.

9. CENTRAL AIR HANDLING SYSTEMS.

a. Air Handling Units.

(1) Package air handling units complete with filters, coils, and fan section shall be used where commercially available. Selection shall be based on efficiency, noise, life of the facility and/or system, and minimum owning and operating cost. Equipment selection shall be in conformance with ARI Standard 430, "Central Station Air-Handling Units."

(2) Unitary air-conditioning equipment is frequently justified when altering existing buildings. Units shall be certified by ARI, where applicable, when tested in accordance with ARI Standard 210, "Unitary Air-Conditioning Equipment." In lieu of ARI certification, the manufacturer shall submit a written certification from a nationally-recognized, independent testing firm to verify unit performance when tested in acordance with ARI Standard 210.

b. Fans. Selection shall be determined on the bases of efficiency, noise characteristics, vibration, physical size, and cost. Attention shall be given to the most economical balance between optimum performance (least energy consumption) and first cost. Fan operating characteristics shall assure stable, nonpulsing aerodynamic operation in the design speed range. Constant volume air handling units and return air fans with belt drives should generally be provided with adjustable motor pulley sheaves to assist in air balancing of systems, with motors of 10 hp or less. Motors greater than 10 hp should use fixed (non-adjustable) drives. Air balancing of belt driven equipment with motors larger than 10 hp should be accomplished by substituting fixed motor pulley sheaves of different diameters. Air handling units and return air fans subject to frequent variations in capacity requirements, in applications such as variable air volume (VAV) systems, may be provided with appropriately selected combinations of variable speed drives, multiple or variable speed motors, inlet dampers, outlet dampers, and scroll bypass dampers to achieve stable operation over the system capacity range. Motors shall not be oversized for unforeseen future capacity needs. Rating performance shall be in accordance with the AMCA Standard. No. 210, "Test Code for Air Moving Devices."

c. Coils.

(1) Heating and cooling coil ratings shall be certified by ARI when tested in accordance with ARI Standard 410, "Forced Circulation Air-Cooling and Air-Heating Coils." In lieu of ARI certification, the manufacturer shall submit a written certification from a nationally recognized independent testing firm to verify coil performance when tested in accordance with ARI Standard 410.

(2) Water preheat coils subject to freezing outside air temperatures shall require full water flow through the coils. There are two basic control arrangements: (a) vary water temperature in coil and (b) vary air flow through the coil. For water temperature mode, a combination 3-way water valve is required, and an in-line water circulator per coil or bank. For the air flow mode, coil face and bypass dampers are required with no water control valves. Safety controls normally include an electric water flow switch (flow restriction) and an aquastat in the water return (low water temperature).

(3) Cooling coils shall be sized for 500 fpm maximum face velocity. Cooling coils for personnel comfort applications only, may be sized for up to a maximum face velocity of 600 fpm in those applications where space restrictions limit coil size. Coils with face velocities exceeding 500 fpm shall be specifically designed to prevent condensate carryover, or employ moisture eliminators. Two-way water control valves are preferred over 3-way valve/bypass arrangements in order to reduce piping requirements and to improve system hydraulic balancing, for multiple coil locations and variable flow systems. However, provisions will be needed to maintain the minimum-required water flow during light load conditions, by use of some 3-way valves and bypass arrangements at selected coil locations; or by use of water pressure relief valve, and bypass, for the system. Automatic drain features should be considered.

(4) Water coils require pipe fittings for determining water pressure drop and water temperature differential to check water-side performance. Complex systems shall have a means for measuring the water flow quantity through the coil or coil assembly.

(5) Face and bypass dampers are recommended for cooling coils serving personnel comfort cooling systems having variable coil load demands and corresponding inside relative humidity problems during light load. The damper arrangement allows the space return air to bypass the coil for necessary sensible heat (reheat) during the dehumidification control cycle in order to lower the space humidity for improved comfort.

(6) Recirculating air systems with outside air winter design temperature below freezing, and with the cooling coils full of water, require either a preheat coil in the outside air intake, in the return air duct to the air handling unit, or in the mixed air stream upstream of the cooling coil. Where the theoretical mixed air temperature is above 32°F, the preheat coils may be omitted if adequate baffling is provided to guarantee positive mixing of the air streams. Additional safeguards may include operating the water pump whenever the outside air stream is below 40°F.

(7) The use of glycol in central chilled water systems, for freeze protection, should be avoided unless economically justified. This is due to the increased water flow resistance (requiring higher pump horsepower), lowered coil heat transfer efficiency, and reduced refrigeration equipment efficiency (reduced tons of available capacity).

d. Air Cleaning Systems.

(1) General. Filters are classified as Type A-High Efficiency Particulate Air (HEPA) Filters; Type B-Air filters that serve inhabited spaces; and Type C-Air filters that serve noninhabited spaces. Type A filters are rated by the DOP Penetration Test as measured in accordance with MIL-STD-282, or other equivalent test method. Type B filters generally are tested with atmospheric dust using the ASHRAE Dust Spot Efficiency Test. Type C filters are rated according to the specific particle size and matter being collected. All filters shall be constructed of noncombustible materials meeting the requirements for Underwriters' Laboratories, Inc., Class I unless otherwise approved by the DOE fire protection authority having jurisdiction (refer to U.L. Building Materials Directory for classification rating). Air filters shall be located on the inlet or suction side of fans except where the system analysis justifies a downstream location. For further guidance refer to ASHRAE Equipment Volume. An air filter pressure drop gauge of the diaphragm-actuated, dial-type (preferred) or the inclined manometer type, shall be installed on all filter assemblies 5000 cfm and larger or as otherwise required. Each

gauge shall be provided with two three-way vent valves for checking the zero setting. Each DOE field installation should establish a filter standardization plan in order to reduce the number of different type filters and replacement media, as an operating cost saving.

(2) Type A Filters.

(a) Provisions shall be made for in-place testing of HEPA filters, with particular attention given to plenum hardware provisions to allow for testing individual HEPA filters without the testing personnel having to enter the plenum. Utility services should be extended to the plenum location (e.g., electrical receptacles and compressed air) to facilitate the testing work. For guidance on in-place testing, see ANSI N101.1, "Efficiency Testing of Air-Cleaning Systems Containing Devices for Removal of Particles"; ANSI/ASME N510, "Testing of Nuclear Air Cleaning Systems"; and ERDA 76-21 (ORNL-NSIC-65-1) Nuclear Air Cleaning Handbook, "The Design, Construction, and Testing of High Efficiency Air-Cleaning Systems for Nuclear Applications." Prefilters (Type B) having 35 percent minimum efficiency should normally be installed upstream of HEPA filters in order to extend the HEPA filter's life unless an analysis of filtration requirements and evaluation of the filter assembly justifies omission of the prefilters.

(b) For guidance in the design and construction of high efficiency air cleaning systems, see ERDA 76-21. In the design, fabrication, and installation of the filter frame assembly (both the fixed frame and removable frame units), it is critical that the installed HEPA filters and frame assemblies are peripherally airtight. The fixed and removable filter frames shall be shop fabricated of suitable metal, or other noncombustible material, with a protective coating to resist corrosive atmospheres. Fixed filter frames shall be designed to accommodate filters in one face only, to assure firm seating of filter seal surfaces. A continuous periphery weld shall be made to the fixed filter frame and metal housing. Combustible caulking, adhesive tapes, and gasket materials shall not be used in the installation of the filter/frame assemblies. Where filter frames are to be installed in a concrete housing, or pit, steel members to which the fixed frames will be peripherally welded should be imbedded in the concrete.

(c) In providing fire protection for the HEPA filters, prefilters or fire screens equipped with water spray shall be separated sufficiently from the HEPA filters to restrict impingement of moisture of 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 assure continued effluent filtration in the event of fire within any portion of the system.

(d) Independent inspection and testing of HEPA filters prior to acceptance from vendors is an important element of the quality assurance program, and shall be performed at one of the following sites:

1 Union Carbide Corporation
Oak Ridge Gaseous Diffusion Plant
Filter Testing Services
Oak Ridge, TN.

2 Rockwell International
Energy Systems Group
Rocky Flats Plant (Filter Testing Facility)
Golden, CO.

3 Hanford Environmental Health Foundation
Richland, WA.

For recommended procedures to be followed in the procurement of HEPA filters, and use of these inspection and testing services, see Environmental Safety and Health Information Issue No. 342, "Filter Unit Inspection and Testing Service," of 9-23-77 (issued by the Division of Operational and Environmental Safety, ERDA). Current service charges may be obtained from any of the three inspection and testing service organizations listed above.

(3) Type B Filters. These filters include those air filter devices and air filter media used in building environmental air handling systems for removing particulate matter from atmospheric air. Filter classification shall be roughing, medium efficiency, or high efficiency (not HEPA filter). These filters shall be specified in conformance with ARI Standard 680, "Air Filter Equipment."

(a) Roughing filter efficiency range is 5 to 25 percent when tested with atmospheric dust. Representative filters include the panel-type and the roll-filter type. Generally based upon 15-year owning and operating costs and for systems less than 5,000 cfm, the panel-type filter with permanent frame and renewable filter media is the least expensive.

(b) Medium efficiency filters are 25 to 75 percent efficient when tested with atmospheric dust. These filters normally have permanent steel frames with replaceable extended dry-surface filter media.

(c) High efficiency filters are 75 to 99 percent efficient when tested with atmospheric dust. The electronic air cleaner and extended dry-surface filter (same as medium efficiency) are included. Prefilters are normally provided; being either roughing or medium efficiency filters depending upon the upstream air particle size distribution.

(4) Type C Filters. These filters are primarily for industrial and process type applications associated with air or gases having heavy dust loadings in exhaust systems or process stack gas effluents. For further guidance refer to the ASHRAE Equipment Volume, and to the American Conference of Government Industrial Hygienists (ACGIH), "Industrial Ventilation Manual."

e. Air Duct Design.

(1) Duct systems shall be designed for efficient distribution of air to the conditioned spaces, giving proper consideration to noise, available space, and an optimum balance between minimum expenditure of fan energy (annual operating cost) and duct size (initial investment). Ducts and duct systems normally shall not be designed for unforeseen future expansion.

(2) Low-velocity duct distribution systems with their low air-pressure drop are normally installed. Particular attention shall be given to duct fittings and fan approach/discharge duct connections in order to minimize vibration, noise, and pressure drop. Where medium velocity duct distribution systems are justified, the maximum duct velocity should be 3,000 fpm. For design guidance refer to the ASHRAE Handbook of Fundamentals, the SMACNA Standards, and the American Conference of Governmental Hygienists (ACGIH) Ventilation Manual. This guidance should not be used for exhaust ductwork that will carry radioactive (or potentially radioactive) air.

(3) Duct work shall comply with NFPA No. 90A, "Standard for the Installation of Air-Conditioning and Ventilating Systems," and NFPA No. 91, "Standard for the Installation of Blower and Exhaust Systems."

(4) Duct air leakage for the air distribution system shall be less than 5 percent for the design air flow and operating pressure.

(5) Fibrous glass ductwork material and closure system shall be in accordance with UL 181, Class I Standard, with NFPA No. 90A and No. 91, and with Factory Mutual (FM) "Loss Prevention Data" (sheets). Duct construction shall be in accordance with SMACNA, "Fibrous Glass Duct Construction Standards." Examples of unacceptable applications of fibrous glass duct and duct liners generally include: electronic equipment rooms, clean rooms, animal research areas and holding areas, respiratory and optic medical treatment rooms, and where toxic, radioactive, or explosive materials could impregnate, become entrapped in, or condense on inner surfaces of the fibrous glass duct

or duct liners. In areas such as mechanical equipment rooms, where the use of fibrous glass duct in exposed locations subject to physical damage would also be unacceptable, use of fibrous glass duct liners would be a suitable alternative.

(6) For additional duct system design criteria for laboratory facilities, see Chapter XVII, paragraph 5, of this Order.

f. Economy Cycle. Air-conditioning systems, except those using room fan-coil units and as indicated below, that require cooling when the outside air temperature is less than 60^{0}F, shall use outside air for cooling instead of mechanical refrigeration. However, outside air fan cooling shall not be used where it is not economically and/or operationally justified. These systems normally use the enthalpy controller for system changeover.

(1) Air handling systems that have the economy cycle and include both exterior and interior zones shall be controlled such that the exterior zone determines the quantity of outside air for cooling. It is important that the interior zone does not precool the air for the exterior zone whereby the exterior zone requires additional heat. Therefore, for interior and exterior zone applications, separate air handling systems shall be installed in order to provide independent, year-around temperature control.

(2) Clean rooms, data processing rooms, and similar type spaces that require year-around temperature and relative humidity control and air filtration normally do not use the economy air cycle because of the increased annual owning and operating costs.

(3) Return air fans are required for positive control of the variable outside air cycle where the return air duct resistance (room to atmosphere) exceeds 0.25 inches water. Systems that maintain constant room pressure balances require a return air fan in order to maintain air pressure balance while under the economizer or variable outside air volume control.

g. Heat Recovery.

(1) Wherever technically feasible and economically justified, based on life cycle cost analysis, heating and air-conditioning systems that require more than 4,000 cfm of outside ventilation air shall have heat recovery equipment, (i.e., the coil runaround or coil loop cycle, rotary heat exchanger, or the nonregenerative heat pipe.) Widely dispersed roof-mounted exhaust air outlets should be combined into a central or multiple central exhaust systems' configuration in order to economically justify heat recovery systems. This equipment is capable of recovering a high percentage of the exhaust air thermal energy, such as for preheating the outside air during the heating cycle and for precooling the outside air during the cooling cycle.

For further guidance refer to the ASHRAE Systems Volume, and the SMACNA "Energy Recovery Equipment and Systems" Manual for design and construction details.

(2) Heat-of-light systems shall be considered where the lighting illumination level exceeds 40 foot-candles and a plenum return air system concept is acceptable. Air heat-of-light systems return the room air through the ceiling fixtures with a reduction in room sensible heat and a corresponding reduction in total supply air and fan horsepower. The wet "troffer" type heat-of-light system can recover a greater amount of heat with a higher first cost.

(3) Thermal energy rejected by refrigeration equipment condensers may be recovered and used for a variety of heating applications. The following guidance is provided.

(a) When water cooled condensers are used and the cooling water (e.g., cooling tower water) is unsuitable for use in the heating equipment under consideration, heat recovery may be accomplished by using double bundle condensers or alternate condensers.

(b) When air cooled condensers are used, heat recovery may be accomplished by a hot gas desuperheater between the refrigerant compressor and the condenser.

(c) When refrigeration thermal energy heat recovery is used in applications such as the perimeter heating of buildings or spaces with year-around interior area cooling loads, the heat balance for the entire building or space design should be optimized on a life cycle cost basis.

(d) When thermal energy heat recovery is used to satisfy a base load heating requirement (e.g., process or domestic water heating) and the heat available from the refrigeration system exceeds the base load heating demand, the refrigeration system should be divided into two parts. One part should be configured and sized to satisfy the heat recovery base load demand. The remainder of the refrigeration load should be satisfied by equipment configured to operate and take advantage of the efficiency inherent in the lower condenser or desuperheater water temperatures used in non-heat recovery refrigeration equipment.

(e) Where the potential exists for cross-contamination of potable water supplies, heat recovery designs may employ vented double-wall condenser or desuperheater tubes, intermediate isolating heat exchanger loops with circulating pumps, or similar devices to achieve compliance with the National Plumbing Code, or applicable local codes.

10. BOILERS.

a. Selection of the boiler type is generally dependent on the total load requirement and type of fuel utilized. Fuel selections shall be consistent with the DOE fuels and energy use policy (see DOE 4330.3, FUELS AND ENERGY USE POLICY). Boilers are rated according to appropriate codes or standards of the American Society of Mechanical Engineers (ASME), American Boiler Manufacturers' Association (ABMA), and the Steel Boiler Institute (SBI)/Hydronics Institute (HI). For most boiler installations an in place capacity test (acceptance test) shall be performed to verify performance.

(1) Modular boiler installations should be evaluated for loads greater than 1,000,000 Btu/hr in order to maintain a high operating plant efficiency throughout the year. Number and size of the boilers would depend on the number of operable hours at full and part load operations.

(2) In comparing steel boilers with cast iron boilers, the ruggedness and dependability of the cast iron boiler shall be evaluated against the lower first cost and ease of installation of package steel boilers.

(3) Outdoor-type boilers shall be considered where economics, climate, size, operable life and operating and maintenance factors are advantageous.

(4) Fully automatic mechanical-firing equipment and mechanical draft equipment are normally installed to match boiler load requirements. Mechanical-firing equipment shall be specified to develop 100 percent to 125 percent of the boiler capacity. For additional information, see FCC Technical Report No. 51, "Combustion Equipment and Related Facilities for Nonresidential Heating Boilers."

b. Load computations that establish the boiler capacity shall be based on the peak design load considering the simultaneous building heating load, process load, distribution losses, and pickup allowance. A credit shall be given to simultaneous interior heat gains from people and electrical lighting. Boiler capacities shall be expressed in British thermal units per hour (Btu/hr) at the required operating pressure.

c. The selection of fuel among possible alternatives (see DOE 4330.3) for heat generation, and the method of firing, shall be determined by an economic analysis of the costs of fuel, construction, operation, storage, handling, maintenance, and environmental pollution control requirements discussed in Chapter XI of this Order. A study shall be made of the advisability of selecting equipment which can be readily converted from one fuel to another, including provisions for storage of each different fuel. Varieties of fuel at each installation shall be kept to a minimum. Where the use of oil is permitted, and the heavier grades of oil are utilized, provisions shall be made to preheat the oil to assure efficient burner performance.

d. See ASHRAE Equipment Volume for general guidance on boiler sizing, types, rating codes, operation and maintenance factors, fuel-burning, and draft equipment.

e. Refer to the NFPA National Fire Codes and improved risk criteria for boiler combustion safeguards, controls, and installation requirements.

11. AIR-CONDITIONING SYSTEM OPERATING EFFICIENCIES. Equipment selection and performance shall meet the minimum requirements in ASHRAE Standard 90-1980.

12. ADIABATIC COOLING.

a. In locations where a wide variation exists between the dry and wet bulb temperatures for extended periods of time as discussed in paragraph 6, above, adiabatic cooling is an inexpensive form of cooling that shall be considered. Selection of cooler types will be dependent upon the system configuration and user experience. Generally, the drip and pad type coolers are used below 10,000 cfm capacity each, whereas the rotary coolers and wet cell air washers are used for larger capacities. It is imperative that all evaporative coolers maintain a positive water-bleed and water-makeup system for control of salt buildup. Spray-coil dehumidifiers also are used in central air handling units.

b. Air duct design, number and location of coolers, and relief of the high supply air rate to the atmosphere shall be analyzed to assure a satisfactory operating system. Two-stage evaporative cooling systems should be considered where the outside air dry bulb temperature during the 6 warmest months is 93°F and higher for an average of 200 hours or more, and the wet bulb temperature is 73°F and higher for an average of less than 100 hours for the same period.

c. For shops and similar large open bay areas, the heating and cooling systems should be combined except where it is not economically or operationally justified. Generally, two-speed fan operation should be used: fast speed during the cooling cycle (100 percent outside air) and slow speed during the heating cycle (100 percent recirculation). Where the difference between heating and cooling air requirements is too great to allow efficient and stable fan operation or acceptable air outlet performance at the lower fan speed, separate heating and cooling systems may need to be provided. Alternatively, a combined system supplemented by a cooling-only secondary system may be the most economical.

d. Indoor DESIGN dry bulb temperatures shall be 80° to 85°F. Average DESIGN operating efficiency shall be 70 percent maximum for the selection of adiabatic cooling equipment. System installed capacity shall be based on the conditioned space peak design heat load. An arbitrary air change rate shall not be used. Adiabatic cooler specifications should be stated in terms of air capacity and the leaving temperature difference between air and water for a given set of entering conditions.

13. MECHANICAL VENTILATION.

a. Utility Rooms. Mechanical and electrical equipment rooms shall be ventilated to maintain ambient temperature levels within allowable NEMA (and other) equipment standards. Where mechanical ventilation cannot maintain satisfactory environments, evaporative cooling systems or other partial cooling systems shall be evaluated. Ventilation air exhaust openings should be located adjacent to heat producing equipment, such as pressure reducing valve (PRV) stations, in order to minimize ambient thermal loads. Thermostatic controls shall be used to operate the ventilation system.

b. Laboratory Ventilation and Exhaust Systems. See Chapter XVII of this Order for laboratory and laboratory hood ventilation and exhaust system design criteria.

c. Air Contamination. Studies shall be made to determine special ventilation requirements for buildings or work areas exposed to radioactivity contamination, or other contamination by toxic, noxious, or explosive solid particles, liquid particles, vapors, or gases. Ventilation systems shall be kept as simple as possible by localizing problem areas within gloveboxes or hoods. Exhaust air treatment shall satisfy applicable requirements in Chapter XI of this Order.

14. CONTROLS AND ZONING.

a. The arrangement and number of temperature-controlled zones are normally established by fire separation area requirements, health and safety hazards, space operational requirements, load fluctuations due to occupancy, exposure, building size and configuration. Automatic temperature and humidity controls shall be installed as required.

b. For administrative facilities and similar occupancies, each major orientation should be zoned to have no more than 2,000 sq. ft. of floor area with exterior exposure, and no more than 3,000 sq. ft. of floor area with no exterior exposure.

c. It is essential that the specified control system accuracy be compatible with the environmental system capability to respond in an accurate and timely manner.

d. Central supervisory control systems shall be installed for individual buildings and/or for installation-wide building utility systems, where economically justified. Where building central supervisory control systems are to be installed, the control consoles should have the capability for expansion to interconnect additional building utility systems. Where use of building or central supervisory control systems are contemplated in the future, selection of controls and instrumentation should incorporate features to allow for simple future interfacing with such systems. See paragraph 12 in Chapter XIII for additional criteria.

e. Automatic temperature control devices for personnel comfort should have a heating control range between 55°F and 75°F and a cooling (where required) control range between 75°F and 85°F. The automatic temperature control system shall not be capable of simultaneous heating and cooling.

f. With the exception of research and process, or other areas that require a constant year-around environment, manually-adjustable automatic control setback and/or shutdown devices shall be provided for all heating and cooling systems in order to reduce the energy consumption during nonoccupied periods. Automatic temperature controllers with reset capability shall be evaluated for equipment such as chillers, reheat coils, and multizone units in order to reduce the consumption of energy by varying the set-point control in accordance with the building load.

g. Electrical equipment load-leveling or load-shedding features shall be provided where economically justified.

h. Safety controls' sequence of operation shall be carefully evaluated to assure a "fail-safe" operation during an emergency in accordance with the NFPA National Fire Codes and/or system safety requirements.

i. Automatic air dampers used for system thermal isolation and air mixing (i.e., outside air dampers and hot/cold air mixing dampers), shall be of the 1 percent leakage type. Shutdown of building environmental systems during unoccupied periods of time has enhanced the need to minimize outside air leakage to the system during extreme weather conditions.

j. For variable air-flow systems the control system shall include the use of the "closed loop" fan volume control, use of industrial controllers instead of commercial grade, and use of air-flow measuring stations with multiple-point pitot type for sensing velocity air pressure.

15. <u>PLUMBING SYSTEMS.</u>

a. <u>Sanitary Drainage.</u>

(1) In sizing the sanitary drainage system, the total load shall be estimated by the fixture-unit method using permissible load values with due allowances, as specified in the National Plumbing Code (or local plumbing code, if applicable), for continuously flowing equipment or devices.

(2) Adequate vent piping, sized to meet the minimum needs, is a requirement of a properly designed sanitary drainage system. Consideration may be given to the single-stack system if found adequate and economically advantageous for the specific application.

(3) A riser diagram of all drainage systems and vent stacks for buildings of two or more stories in height shall be shown on the construction drawings in order to provide a clear identification of the plumbing installation requirements.

b. Sanitary Fixtures.

(1) Location of fixtures shall be determined by functional requirements and shall meet applicable requirements for the physically handicapped. The number of toilet fixtures to be installed shall be based upon the type of facility, the number and sex of persons served, the type of fixtures, and the table of allowances for minimum facilities listed in the applicable code. All plumbing fixtures shall be located at a sufficient height to permit gravity discharge to the sewer. Installations where plumbing fixtures cannot be located to permit gravity draining shall be protected by appropriate back-water valves and automatic sewage ejector systems.

(2) Special purpose fixtures shall be based on minimum actual needs. Laboratory services are covered further in Chapter XVII of this Order.

c. Water Supply and Distribution.

(1) Cold Water Service Connection. Wherever possible, service entrances shall be sized to provide sufficient flow at required pressure for all fixtures without the use of pumps. Large buildings may be supplied by two or more service entrances for balanced supply. The sizing of service entrances shall be in accordance with applicable codes and standards, using the minimum pipe size practicable without excessive noise-producing velocities or wasteful pressure losses.

(a) Where potable and nonpotable water supplies are required in the same building, care shall be taken to prevent cross-connections and consequent contamination of the potable water supply. When different uses are made of potable supplies, and the requirements dictate, care shall also be taken to prevent cross-contamination of these supplies. Practices recommended in AWWA Manual M14 shall be followed, and backflow prevention devices meeting AWWA Standard C506-69 shall be specified. Water supplies to areas where radioactive materials are handled shall be protected by approved air gap installation or backflow prevention devices.

(b) Water supply requirements for fire protection systems are covered in Chapter X of this Order.

(c) An entrance pressure of 80 pounds per square inch (psi) on the domestic water service shall be the maximum pressure allowable without the installation of a pressure-reducing valve. Processes requiring higher pressures shall be isolated from the general service facilities to conserve water and to provide better operating conditions. A minimum terminal pressure for fixtures shall be maintained (e.g., wall-hung water closets may require 25 psi and lavatories may require 8 psi). Where this pressure cannot be obtained by gravity, a satisfactory system shall be specified for maintaining adequate flow at proper pressure.

(2) Plumbing and Storage. Where the water pressure in the outside mains cannot maintain the required flow and pressure in the extremities of the building system, suitable pumping facilities shall be provided, such as:

(a) Tankless water supply system using house booster pumps. This type system is desirable when a pressure shortage occurs in the main for a short period or where an increase of pressure is required on a system with a good average water demand.

(b) A pneumatic water system. This system is advantageous where the water demand is intermittent, to relieve strain on the pumps and piping.

(c) A high-level water booster system with adequate water storage. This should be considered for multistory buildings. Usually a downfeed system will prove more economical with this type of installation.

(3) Domestic Hot Water Temperatures. Domestic hot water storage design temperature shall be limited to 110°F. Cooking, process, laboratory, or other special requirements for water in excess of 110°F normally shall be provided by independent boosters to prevent unnecessary exposure of an entire system to excessive temperatures. Circulating hot water systems designed to provide a temperature difference of 20°F maximum between the source and the return shall be installed where justified for a process requiring immediate hot water, or where an excessively long developed length of piping from the source to the point of usage causes an unreasonable amount of time to elapse before hot water becomes available (nominally 50 feet). When hot water circulating systems are provided, they shall be equipped with timers to shut down the circulating pump during unoccupied periods; and the piping shall be insulated in accordance with Federal Construction Guide Specification (FCGS) Section 1516, "Insulation of Mechanical Systems," Table II. Lavatory fixtures shall use a single spray head type faucet that has a flow restrictor to provide approximately 0.25 to 0.50 gpm water flow. Utility rooms may have both hot and cold water for cleaning purposes.

(4) Hot Water Heating and Storage. The total demand for domestic hot water for large buildings shall be estimated on the basis of the designed occupancy, using the values in the ASHRAE Systems Volume for each particular type of building. Hot water demand for small buildings (50 persons or less) may be estimated on the basis of fixture-units. Individual studies shall be made for other facilities with unusual or heavy demands. The selection of domestic hot water heaters shall be based upon an economic balance of the maximum daily demand, the maximum hourly demand, the first cost of equipment, operating costs, availability and cost of fuel, the quality of the water, and the space required. The economic and energy conservation aspects of heating or preheating domestic hot water from waste heat recovery or solar energy sources shall also be evaluated in the selection of domestic hot water heating systems. Integration of these factors will usually result in selection of one of the following types:

(a) Indirect Equipment with Storage. In buildings where adequate steam is available throughout the year, domestic hot water normally shall be heated with steam, using a storage tank with interior U-bend tube heating coils. Storage-type heaters may be either vertical or horizontal depending upon available space and other local factors. They shall be selected with a storage capacity equal to one-half the estimated hourly requirement and with a heating element having an hourly recovery capacity equal to the estimated hourly requirement through the temperature range established for the particular type of building. A tank as near as possible to the computed size shall be selected; however, the actual dimensions will be determined by space conditions and the stock sizes available. If the storage capacity of the selected tank is appreciably less than the computed requirement, the size of the heating element shall be based on a ratio of recovery to storage capacity of two-to-one. The stock size heating element, next larger than computed, shall be selected unless the computed rating is coincident with the stock size.

(b) Instantaneous Heating Equipment. Where the hot water demand is continuous with little fluctuation of requirements or intermittent and below 5 gpm and where steam is the most economical heating medium available, a nonstorage, instantaneous heater may be advantageous. Instantaneous heating equipment capable of supplying large intermittent demands is available. The economies of this type equipment should be evaluated.

(c) Integrally-Fired Direct-Storage Heaters. These heaters, preferably fired by gas, are normally used in small buildings where demand is small and intermittent. The heaters shall be self-contained, storage-type, insulated, and metal-jacketed. Where an unusual requirement precludes the use of any of the above types of heaters, oil- and coal-fired heaters may be used to accommodate existing conditions, provided pollution control standards are met. The need for chimneys, vents, and fuel storage for gas, oil, or coal shall be considered in evaluating equipment suitability. Oil, gas, or solid fuel installations shall conform to NFPA Codes. Water heating by electricity shall be restricted to small buildings with one or two lavatories, not subject to frequent use, but requiring a ready supply of hot water; or restricted to facilities where electricity is the only readily-available and economic energy source. The design of any hot water system shall include the required safety devices.

(5) Hot and Cold Water Supply Piping. Hot and cold water supply piping shall be sized in accordance with the recommendations in the ASHRAE Systems Volume and/or the National Plumbing Code (or local plumbing, code, if applicable) using the fixture-unit rating method. The values for fixtures not listed shall be obtained by comparison to listed fixtures. In evaluating material for use in hot water distribution systems, the effect of high temperature and the possible need for an allowable increase in pipe sizing for scale accumulation shall be considered. Where water characteristics may cause rapid deterioration of the hot water system, the use of suitable water treatment equipment shall be evaluated. Installation of a gravity or pumped-circulating system shall be based upon the comparative costs of the two systems.

(6) Water Fountains. Self-contained, mechanically-refrigerated cooler ratings shall be certified by ARI when tested in accordance with ARI Standard 1010, "Drinking Fountains and Self-Contained Mechanically Refrigerated Drinking-Water Coolers." In lieu of ARI certification the manufacturer shall submit a written certificate from a nationally recognized independent testing firm to verify the manufacturers ratings when tested in accordance with ARI Standard 1010. Usually, self-contained mechanically refrigerated drinking fountains are more economical than wall-hung fountains supplied from a central chilled-water system. Drinking fountain units shall comply with the requirements of the National Plumbing Code (or local plumbing code, if applicable). Corridor locations should be recessed. Location and types of fixtures shall meet applicable requirements for the physically handicapped.

16. DISTRIBUTION SYSTEMS. Generally, for industrial facilities all interior piping shall be run exposed, and all duct work shall be run exposed for forced warm-air systems. Where piping and duct work are concealed, accessibility to valves, dampers, control instruments, and so forth, shall be provided and identified. Steam and water distribution piping systems shall be sized to maintain flow below the velocities at which objectionable sounds and erosion may occur in the system. Recommended design criteria are contained in the ASHRAE Systems and Fundamentals Volumes.

17. MECHANCIAL SYSTEMS INSULATION.

a. Insulation for ducts, piping, and heat-producing equipment shall be provided where resulting economies will offset the cost of the insulation within its life expectancy, or where required to prevent damage or unsatisfactory working conditions from heat or condensation. The insulation shall be selected to obtain maximum economy with minimum maintenance, repair, or replacement and comply with fire protection requirements. In economic studies, the life expectancy of the insulation shall be assumed to be not over 20 years for laboratory and administrative-type applications, and not over 10 years for industrial process type applications. Insulation (coverings and linings) shall conform to the requirements of NFPA 90A, "Air Conditioning and Ventilation Systems." The flame spread and smoke developed ratings shall be clearly labeled on the material to be specified, procured, and installed. For additional design guidance, see the Thermal Insulation Manufacturers Association (TIMA) "Economic Thickness Manual."

b. Pipe insulation and other similar insulating materials containing friable, loose, or unbonded asbestos fibres shall not be used; except where no alternative material is available or feasible for the particular application and approval is obtained from the DOE health and safety authority having jurisdiction, on a case-by-case basis. Similarly, insulating materials where asbestos fibres have been modified by a bonding agent, coating, or other manufactured treatment, shall not be used unless it can be assured that during any use, handling, storage, disposal, processing or transportation, airborne fibres will not be released in excess of allowable concentrations. All asbestos or asbestos-containing materials' usage shall conform to the following Federal regulations:

(1) Title 29, Part 1910, Subpart Z, Section 1001, "Occupational Safety and Health Administration Standards for Permissible Exposure to Airborne Concentrations of Asbestos Fibres."

(2) Title 40, Part 61, Subpart B, "National Emission Standards for Asbestos."

18. FIXED INTERIOR FIRE PROTECTION REQUIREMENTS. Criteria for interior fire protection are contained in Chapter X of this Order.

19. INCINERATORS. Waste incineration for individual facilities should not be selected where other means of waste disposal will be suitable, and more economical from a life cycle cost standpoint. Where incineration is required for a number of dispersed facilities, consideration should be given to providing a central incinerator capable of serving the entire complex. Where the principal consideration is the protection of classified information by destruction of paper documents, approved paper disintegrators should be evaluated for use instead of incinerators. See paragraph 3b, in Chapter XI of this Order for additional criteria.

a. Incinerator Features and Combustion Auxiliaries. Incinerators shall be designed to burn efficiently with minimum environmental impact. Consideration shall be given to the use of auxiliary fuel and after-burners to assure complete combustion and maintain in-flue gas temperatures at sufficient level for odor elimination. Generally, incinerators having capacities of 800 lbs/hr or more shall have fully automatic charging, and have provisions for fly ash removal, auxiliary firing, and automatic control. Incinerators to be used for the disposal of industrial wastes other than wood-product materials generally will require special design based on the particular waste or combination of wastes to be burned.

b. Draft Auxiliaries. All incinerators shall be equipped with an automatic draft regulator and shall be connected to a chimney, flue, or stack of adequate height and cross section to provide ample draft for capacity operation. Adequate air shall be supplied to the incinerator to assure complete combustion. Incinerator design generally shall include controlled secondary air supply.

c. Flue Gas Cleaning and Smoke Detection. The need for flue gas cleaning devices, emission (opacity) monitors and alarms, and gas and particulate analyzers, will depend on the type of waste(s) to be incinerated, facility location, and applicable pollution control regulations and standards. Such devices are recommended for incinerators where the potential exists for overloading with resultant incomplete combustion, and associated potential for violating emission standards.

d. Equipment Selection and Pollution Control. Basic data for design of incinerator facilities is contained in the Environmental Protection Agency (EPA) publication No. SW13TS, "Municipal Scale Incinerator Design and Operation Manual," latest edition.

e. Fire Protection. Combustion controls and other features shall be in accordance with NFPA 82, "Incinerators, Waste and Linen Handling Systems and Equipment."

20. SYSTEM PERFORMANCE TESTS.

a. Complex mechanical environmental systems shall require system performance tests to verify compliance with construction and operating requirements. These tests should be performed by an independent testing organization. Where testing organization services are used, the testing firm shall be a member of the Associated Air Balance Council (AABC), or certified by the National Environmental Balancing Bureau (NEBB), or meet the technical standards for membership of the AABC as published in the AABC "National Standards for Field Measurements and Instrumentation--Total System Balance," except that affiliation with engineering firms may not preclude their acceptance.

b. Testing procedures for air and water-side systems shall generally be in accordance with the guidelines contained in the ASHRAE Systems Volume, including the referenced detailed information from AABC, SMACNA, and CSI.

c. Major equipment, e.g., water chillers, cooling towers, water pumps, and central coil banks, should have permanently installed calibrated devices to accurately measure water flow and temperatures. Pump curves shall not be used for determining system flow quantities, although these curves may be used for analyzing pump performance under varying operating conditions. Typical testing devices include thermometer wells, gage cocks, orifice plates, and venturi tubes. Location of measuring points shall be identified on the construction drawings. Duct mounted air flow monitoring devices may be used for measuring air volume flows where limited duct space and/or configuration restrict the use of pitot tube traverse procedures.

d. Where feasible, and warranted by the mechanical environmental systems' complexities, the selected testing firm should also be utilized in the review of the mechanical systems drawings and specifications prior to construction in order to identify and correct design deficiencies that could preclude or inhibit future adjusting, balancing, and effective testing. Following acceptance of the testing firm's final systems operation report, all balancing devices (air and water) shall have their settings permanently marked to permit restoration of original settings in the event the control settings are altered.

21. OPERATING AND MAINTENANCE (O&M) INFORMATION AND DATA. The construction contractor or other designated party shall be required to prepare and deliver to the DOE construction contracting officer (or designee) the following operation and maintenance information, as a minimum. See paragraph 3m in Chapter I of this Order for other criteria, O&M information and data requirements.

a. Schematic and one-line drawings of mechanical systems to assist in the understanding of system complexity and purpose by facility operating and maintenance personnel; and for record purposes.

b. Dimensional drawings and installation instructions.

c. Operating and maintenance instructions for equipment and systems.

d. Copies of equipment catalog data and a listing of spare parts.

e. Listing of special tools for adjustment and maintenance of equipment and systems.

f. Final systems' performance test data that reflect technical compliance with contract requirements.

g. Outline of color and legend code for building utility services (normally the operating contractor estabishes the utility systems color coding to assure onsite standardization).

CHAPTER VI

INTERIOR ELECTRICAL SYSTEMS

1. COVERAGE. These criteria shall be applied in the selection of the electrical service method and in the planning and design of interior electrical systems for DOE facilities. Additional criteria for specific facilities are contained in other chapters of this Order, beginning with Chapter XVI. Criteria for exterior electrical systems are contained in Chapter VIII of this Order.

2. CODES, STANDARDS, AND GUIDES. In addition to the latest edition of the National Electrical Code (ANSI/NFPA-70), the latest edition of the codes, standards, and guides listed below shall also be followed.

   a. National Fire Protection Association (NFPA) National Fire Codes.

   b. American National Standards Institute (ANSI) Standards.

   c. National Electrical Manufacturers Association (NEMA) Standards.

   d. Institute of Electrical and Electronics Engineers (IEEE) Standards.

   e. Underwriters Laboratories, Inc. (UL) Standards and "Product Directories".

   f. Insulated Cable Engineers Association (ICEA) Standards.

   g. Factory Mutual (FM) "Approval Guide," and FM "Loss Prevention Data."

   h. Illuminating Engineering Society (IES) Lighting Handbook.

   i. DOE/EV-0051/1, "Electrical Safety Criteria for Research and Development Activities," of 9-79.

   j. Department of Labor, "Occupational Safety and Health Standards," Title 29, Code of Federal Regulations (CFR), Part 1910.

   k. General Services Administration, Federal Supply Service, "Federal Standards" and "Federal Specifications."

   l. Federal Construction Council, "Federal Construction Guide Specifications;" and Technical Reports Number 46, "Diesel Engines for Use with Generators to Supply Emergency and Short-Term Electric Power," and Number 42, "Continuously Operating Diesel Engines for Electrical Power Generators."

3. PLANNING. Careful planning and design of electrical systems is necessary to assure that initial and projected power requirements will be satisfied, with regards to quantity, quality and reliability, and that safety, energy conservation, and operating and maintenance requirements are being satisfied. The National Electrical Code, ANSI/NFPA-70, establishes minimum standards of

design that shall be followed. Where more stringent requirements are contained in this Chapter VI, these requirements shall take precedence. Electrical system materials and equipment shall conform to applicable standards of those organizations listed in paragraph 2, above.

a. Electrical Loads. Estimated electrical loads shall be based on initial power demands plus anticipated future load growth. Load diversity factors shall be appropriately applied. For guidance see the Institute of Electrical and Electronics Engineers (IEEE) Standard 141, "Recommended Practice for Electric Power Distribution for Industrial Plants," and IEEE Standard 241, "Recommended Practice for Electric Power Distribution in Commercial Buildings."

b. Service Characteristics.

(1) Facility Service. In the selection of facility service voltage, factors to be evaluated shall include the following:

(a) the initial and projected facility loads and load characteristics (motor loads, lighting loads, and other loads and their proportions to the total facility load);

(b) power utilization equipment characteristics as a function of voltage;

(c) power quality and reliability needs of the facility;

(d) power supply options (from low voltage site distribution systems, medium voltage primary distribution systems, or from commercial utility systems);

(e) distance to the supply source(s);

(f) short circuit current characteristics of the power supply system(s) at the point of facility; and

(g) investment and operating maintenance costs of power service options and the facility's main service equipment.

1 For a facility where there is no equipment requirement for three phase power and the facility load does not exceed 75 kVA, low voltage, single phase service (240/120-volt) should be used.

2 For other facilities having loads on the order of 500 kVA or less, low voltage, three phase service should be used. Service at 480Y/277-volt should be given preference over lower voltage, three phase service (e.g., 208Y/120-volt). This is particularly appropriate from the standpoint of economics, but also where there will be significant motor

loads to be supplied in the facility. From the standpoint of internal facility power distribution system costs, alone, there will seldom be sufficient reason for selecting the lower voltage service. Lower voltage service distribution system costs will be greater because of the higher current required per kVA of load served and associated increased circuit breaker ratings and conductor size requirements.

3 Higher voltage, three phase service (e.g., 2.4 kV, 4.16 kV, or 13.8 kV) should be used for facilities having loads greater than 500 kVA, and for loads less than 500 kVA where power quality or reliability requirements, or the characteristics of the load to be served, dictate the need. Consideration should be given to the improved reliability and greater voltage stability that can generally be expected from medium voltage primary power supply, and to the size of the facility motor loads that will need to be served. Motors in the range of 150-200 hp and larger should be operated from a 2.4 kV or higher voltage service, except where lower voltage service is determined to be adequate and cost effective.

(2) Distribution Voltages. Voltages selected for internal power distribution should be the highest level consistent with the types of loads to be served. A 480Y/277-volt system will generally be the best selection for most facilities, particularly where a significant portion of the facility load will be motor load. With this system, small appliance loads, convenience outlets, and other loads requiring lower voltage supply are served from dry-type 480-volt to 208Y/120-volt step down transformers. Lighting loads will usually be supplied at 277 volts. A 208Y/120-volt system may be the most economical method for smaller facilities and where the major portion of the load consists of 120-volt utilization equipment, and the average length of feeders is less than 200 feet. For facilities having loads of 75 kVA or less, and no requirements for three phase service, as identified in paragraph 3b(1)(a), above, the conventional 240/120-volt single phase internal distribution system would be used.

c. Power Supply Reliability.

(1) Where operating continuity or health, safety, or security requirements will require greater power supply reliability than can be assured by a single incoming power service, or a single service in combination with a standby source of emergency power to supply vital systems and equipment, dual incoming power services may be needed. Where dual services are to be provided, the capacity of the second service, for automatic or manual load transfer features will depend upon the specific operating continuity or health, safety, or security requirements. If provided, the dual services should be sufficiently separated, physically, to minimize the possibility of simultaneous service outages from

natural or other causes, and should be supplied from separate substation or generation sources where this degree of electrical supply separation is feasible and justified.

(2) In lieu of providing dual incoming services, a single service supplied from a looped distribution system (e.g., medium voltage primary looped distribution system), having the necessary automatic or manual sectionalizing features to provide the degree of power supply reliability needed for the facility, may be adequate. But, in this case special attention will need to be given to the reliability of the single incoming service.

(3) The need for multiple transformer-switchgear service equipment, to assure power supply continuity within the facility during scheduled or emergency equipment outages, also needs to be evaluated.

d. Emergency Power Requirements. The need for an emergency power system shall be evaluated by identifying those system or equipment components whose operating continuity is vital for safeguarding health, life, property, and accomplishment of operating requirements. The type of emergency power source to be provided will depend upon the operating needs of the system or equipment served. Where generator systems are to be provided, they shall meet the criteria in paragraph 4b, below. Storage battery systems, or small storage battery-inverter systems, will have application as an emergency power source for alarm and control systems, communications systems, and limited-size emergency lighting systems.

e. Power Quality Requirements. Power quality requirements for systems and equipment within the facility shall be evaluated, and the necessary provisions made to minimize adverse effects of voltage level variations, transients, and alternating current frequency variations on critical or sensitive equipment operation.

(1) Large building loads such as central air conditioning equipment or other repetitive "start-stop" types of equipment such as elevators, should be supplied directly from low impedance power sources; i.e., having a sufficient degree of electrical isolation to minimize their operating impact on critical or sensitive equipment, building lighting systems, and so forth.

(2) For equipment requiring a high degree of voltage and frequency stability in power supply and/or requiring operating continuity through periods of short-term power outages, such as computer/automatic data processing systems, vital control systems, or systems critical to safety, an uninterruptible power supply (UPS) system may be provided. It is important that careful attention be given in the selection and application of these systems. The services of qualified engineers in UPS applications, and in the applications of existing or new emergency

engine-generator systems as backup protection to these or other critical loads, should be utilized to assure that the systems selected will satisfy the operating requirements.

f. Operating and Maintenance Requirements. Facility planning shall include consideration of operating and maintenance requirements for electrical systems and equipment for the life of the facility. Safety of life for facility occupants, the public, and for operating and maintenance personnel, and protection of property are two of the most important factors in the planning and design of electrical systems. Simplicity of systems and equipment operation shall be a principal objective. Design of the electrical system shall include considerations for preventive maintenance, and for repair and replacement of equipment. Safe accessibility for inspection and repair are important considerations in selecting and locating equipment. Space needs to be provided for inspection, adjustment, and repair in clean, well-lighted, dry, ventilated, and temperature-controlled space. The equipment should be located such that replacement, as well as repairs, can be accomplished without the need for dismantling or removing other equipment.

g. Energy Conservation. System planning, and equipment selections, shall include consideration of energy conservation objectives to maximize efficient energy usage, and to minimize energy losses within the electrical system, on a life cycle cost effective basis.

h. Energy Management Systems and Devices.

(1) In the planning and design of interior electrical systems for DOE facilities, and when existing facilities are surveyed for energy conservation retrofit opportunities, compatibility with energy management systems and devices and the potential benefits from their use shall be considered.

(2) Criteria on energy management systems and devices are contained in Chapter XIII of this Order.

i. Safety. For specialized research and development electrical equipment and systems, where the nationally recognized codes and standards do not provide sufficient coverage, careful attention shall be given in planning the electrical systems to assure that adequate electrical safety will be achieved. More specialized criteria that cover these types of equipment and systems are contained in DOE/EV-0051/1, "Electrical Safety Criteria for Research and Development Activities."

4. SERVICE EQUIPMENT.

a. Main Service. Main service equipment shall be located in nonhazardous, well-lighted, clean, dry, corrosion-free, ventilated, temperature-controlled, and accessible space. Equipment shall be properly identified by labeling or stenciling at the time of installation. Where indoor transformer-switchgear vaults, indoor emergency power equipment rooms, or other large indoor equipment installations are included in the facility, they shall be so located to provide direct access to outside open areas for ease of equipment installation, and removal, and in such manner that replacement, as well as repairs, can be accomplished without the need for dismantling or removing other equipment.

(1) Metering. See paragraph 13 in Chapter XIII, of this Order for energy metering requirements for new buildings and building additions. Generally, conventional kilowatt-hour meters are appropriate for measuring and recording electric energy use at the incoming power service to the building and at the internal service point(s) to distinct 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 capability may also be needed. In the selection of metering devices, consideration shall be given to their compatibility for use with an existing or projected energy monitoring and control system (EMCS). Where a facility is to be served directly by a local utility company, metering requirements, equipment to be provided, and metering equipment locations shall be coordinated with the supplying utility company. Factors affecting metering requirements will include the applicable utility rate structure, class of service, power demand and power factor penalties, and other conditions of the service agreement.

(2) Switches. Service disconnect devices shall be located as close as practical to the point of service entrance. Switching and switchgear facilities and arrangements shall satisfy the system flexibility requirements with minimum operating complexity.

(3) Transformers.

(a) The number of outdoor or indoor transformers provided for service to or within the facility shall be kept to the minimum necessary, consistent with initial and projected facility loads and operating continuity or other critical requirements. Standard unit-type substations shall be used, where feasible, for power transformer installations. Power transformers shall be equipped with integral forced air fan cooling, or with suitable provisions for adding forced air cooling, and temperature indicators or alarm features.

(b) Power and distribution transformers shall be furnished with standard high voltage winding taps for voltage adjustment purposes. Spare power transformers, or duplicate transformers in a double-ended transformer/switchgear arrangement, should be provided where operating continuity requirements or other critical requirements dictate the need. Due consideration shall be given to transformer maintenance requirements over the life of the facility. Best current data should be used in estimating the mean-time-between-failure (MTBF) for major transformer and switchgear equipment. The estimated life of equipment is a function of the operating conditions to which the equipment will be subjected, and the type and degree of inspection and preventive maintenance to be provided, over the life of the facility.

(c) Indoor and outdoor dry-type and liquid-insulated transformer installations shall comply with applicable requirements in Article 450 of the National Electrical Code.

1 Flammable liquid-insulated transformers shall be located outside of buildings wherever feasible. If located indoors, their installations shall be in accordance with the vault, automatic fire suppression, ventilation, drainage, and other requirements of Article 450-26. Outdoor installations of flammable liquid-insulated transformers shall comply, at a minimum, with the requirements of Article 450-27. Particular attention should be given to separation from buildings and combustible material, and the need for fire-resistant barriers, automatic water spray systems and oil-spill containment. Where water spray systems are provided, they shall comply with NFPA 15 requirements. Where high fire point liquid-insulated transformers are to be used indoors, their installations shall conform to the requirements in Article 450-23. These transformers have been designed to replace askarel-insulated transformers, and the high fire point liquid-insulating dielectrics are less flammable than the mineral oil used in oil-filled transformers but not as fire-resistant as askarel.

2 A major component of any askarel fluid has been polychlorinated biphenyl (PCB), a chemical compound that has been designated by the Environmental Protection Agency as a harmful environmental pollutant. Because of environmental objections to the sale, use, and disposal of PCBs, such nonflammable liquid-insulated transformers are generally no longer available for purchase. See EPA regulations on the handling and use of PCB liquids, in 10 CFR 761, "Polychlorinated Biphenyls." Current Federal standards require, in any case, that liquid insulated transformers (and other liquid-insulated electrical equipment, such as capacitors) not contain PCBs or similar known environmental/health hazards beyond the toxic limits of 50 ppm. Therefore, selection of transformers will usually be limited to the flammable liquid-insulated type, high fire point liquid-insulated types, or the dry-type. However, dry-type transformers still have size limitations. In the planning and design of transformer installations, and particularly for either of these liquid-insulated types, advice and guidance shall be obtained from the DOE fire protection authority having jurisdiction.

b. Emergency Power Systems. Emergency power systems, or "standby systems" (if legally required), shall conform to requirements in Article 700, Emergency Systems," Article 701, "Legally Required Standby Systems," and Article 517, "Health Care Facilities," the National Electrical Code, as appropriate. The systems shall also conform to applicable requirements in NFPA 101, "Life Safety Code." Design should conform to IEEE Standard 446, "Recommended Practice for Emergency and Standby Power Systems."

(1) Where emergency generators are required, combustion engine-generators or gas turbine-generators may be provided. Steam turbine-generators may also be provided where feasible, and where there is a continuous steam supply. Where combustion engines are to be used, diesel engines shall usually be provided. For small loads (e.g., less than 25 kVA), gasoline or liquified petroleum gas (LPG) engines may be used, where the increased fire/explosion hazards can be controlled adequately.

(2) These types of equipment shall be carefully sized to satisfy only the requirements for safeguarding health, life, property, and critical operations, and to provide effective security of DOE facilities. For guidance in the selection of diesel engines, see Federal Construction Council (FCC) Technical Report No. 46, "Diesel Engines for Use with Generators to supply Emergency and Short-Term Electric Power." For longer-duration emergency power requirements, see FCC Technical Report No. 42, "Continuously Operating Diesel Engines for Electrical Power Generators."

(3) Equipment selected shall have electrical output characteristics and quality of power supply (i.e., voltage and frequency stability) to satisfy the power requirements of the loads to be served.

(4) Engine or gas turbine units, including fuel supply and exhaust systems, and appurtenances, and their installation, shall conform with the requirements of NFPA 37, "Installation and Use of Stationary Combustion Engines and Gas Turbines."

5. WIRING METHODS AND MATERIALS. All wiring methods and materials shall comply with the National Electrical Code (NEC). Electrical materials and equipment shall also conform to applicable standards of the Underwriters' Laboratories, Inc. (UL), or other recognized testing agencies or laboratories, to the maximum extent practicable.

a. Wiring Methods. Wiring systems shall be designed so that all components operate within their capacities and with allowances for anticipated load growth.

(1) Emergency power and emergency lighting circuits shall not be run in the same conduit or raceway with normal power or lighting circuits. Consideration shall be given to complete physical separation, including routing.

(2) Feeder and branch circuit voltage drops should not exceed NEC recommended values.

(3) Feeder circuits for power supply to essential services, such as alarm and building evacuation lighting systems, fire pump equipment, and essential telecommunications services may be connected to the power service, with separate disconnect switch and overcurrent protection on the line side (incoming side) of the main power service disconnects. Auxiliary power services for these essential services may consist of emergency standby generators or uninterruptible power supplies.

b. Wiring Materials.

(1) Conductors.

(a) Conductors for interior electrical systems shall be copper; except that aluminum conductors of No. 4 AWG and larger sizes may be used.

1 For aluminum conductors, special attention shall be given in selection of proper cable connectors (terminators). Set-screw terminators shall not be used. Anti-oxidant joint compounds recommended by the manufacturer shall be used to assure the maintenance of high conductivity and prevention of corrosion. Terminators shall be UL listed aluminum, factory filled with anti-oxidant compound, marked "AL-CU" for use with either copper or aluminum, compression type for use with manufacturer's recommended tooling; or other UL listed types approved for use on aluminum, and recommended for the specific application. Antioxidant compounds used shall be compatible with the conductor insulation. For additional guidance on terminating aluminum conductors, and connecting aluminum terminating lugs to copper or aluminum pads and use of Belleville washers, see Chapter 10, "Cable Systems," of IEEE Standard 141.

2 For existing aluminum conductor terminations that do not meet these criteria, and where overheating and related hazard potentials exist, consideration shall be given to reterminating with the proper connectors. Where this may not be feasible in confined spaces, the provision of aluminum-to copper transition sections, and use of the simpler copper cable terminators, should be considered.

(b) Conductors for power and lighting branch circuits shall be No. 12 AWG, minimum.

(c) Conductors for control circuits should be No. 14 AWG, minimum. Conductor sizes for remote-control signalling and power limited circuits, fire protection signalling systems, and communication circuits, shall be in accordance with NEC Articles 725, 760, and 800.

(d) Electrical branch circuit and interior supply-side circuit conductors shall be suitably color coded, or otherwise labeled, in such manner to be consistent with National Electrical Code requirements and with any existing color coding or labeling system used at the particular site for ungrounded circuit conductors. This coding or labeling shall identify voltage levels, the grounded conductors, the equipment grounding conductors, and ungrounded single-phase or polyphase conductors. The color coding for low voltage electrical systems, shown below, is suggested for use where it does not conflict with existing color coding systems for ungrounded circuit conductors at the particular site.

1 For 240/120-volt, single-phase, systems:

Grounded neutral - white
Grounding conductor - green or bare
One hot (ungrounded) conductor - black
One hot (ungrounded) conductor - red

2 For 208Y/120-volt, 3-phase, systems:

Grounded neutral - white
Grounding conductor - green or bare
One hot phase (ungrounded) conductor - black
One hot phase (ungrounded) conductor - red
One hot phase (ungrounded) conductor - blue

3 For 480Y/277-volt, 3-phase, systems:

Grounded neutral - gray
Grounding conductor - green or bare
One hot phase (ungrounded) conductor - brown
One hot phase (ungrounded) conductor - orange
One hot phase (ungrounded) conductor - yellow

(2) Raceways.

(a) Selection and installation of raceways elbows, couplings, and other fittings shall be in accordance with the provisions of the National Electrical Code, with the following restrictions:

1 Neither aluminum conduit nor electric metallic tubing (EMT) shall be embedded in concrete or buried in earth.

2 Only noncombustible raceway shall penetrate fire-rated walls, floors, or ceilings. Raceway penetrations shall be suitably sealed to maintain the established fire ratings.

3 Surface Wireways (National Electrical Code Article 352), Multioutlet Assemblies (Article 353), and Wireways (Article 362) shall not be wall or partition mounted at elevations less than 4-feet above floor level unless suitable protection against physical damage is provided.

(b) Conduit and other raceways embedded in concrete or masonry should be adequate in number and capacities for the initial and projected facility requirements. Embedded conduits shall be not less than 3/4 inch in size.

(c) The newer intermediate ferrous metal conduit (IMC) shall be used in lieu of conventional rigid ferrous metal conduit wherever feasible. Both are recognized in the National Electrical Code as equivalent for use, and IMC has significant purchase cost advantages. Because of the lesser wall thickness and somewhat different material properties of IMC as compared to rigid ferrous conduit, the IMC manufacturer's recommendations for conduit threading and bending need to be followed. Greater consideration also needs to be given to the use of rigid aluminum conduit, except for the restriction in paragraph (2)(a)1, above.

(d) Electric metallic tubing (EMT) shall also be considered for wider use, in lieu or rigid metal conduit or IMC, except where the conduit would be subject to severe physical damage or corrosion damage, including the use restriction in paragraph (2)(a)1, above.

(3) Panelboards and Circuit Breakers.

(a) Low voltage panelboards for lighting and power distribution should be of the dead front type in NEMA 1 general purpose enclosures, or in higher NEMA-rated enclosures as required for the conditions to be encountered.

(b) Branch circuit breakers should be of the bolt-on, thermal magnetic, molded case, overload and short circuit type; with a minimum trip rating of 20 amperes and a minimum interrupting rating of 10,000 amperes. The use of molded case circuit breakers in panelboards should be limited to no greater than the 1,200 ampere trip-rating size.

(c) Where molded case circuit breakers of the "systems type" of from 1,200 to 4,000 ampere trip-rating sizes are to be used, they should be of the drawout type, with contacts accessible for inspection and replacement, and with suitable ground fault protection features.

(4) Receptacles. All electrical receptacles shall be specification grade and standard NEMA configuration types.

6. INTERIOR LIGHTING.

a. Lighting Levels. In the design of interior lighting systems, non-uniform lighting principles shall be applied, consistent with the lighting conservation policies for existing lighting systems in the Federal Property Management Regulations (FPMR), 41 CFR Subchapter D, Part 101-20.116-2. The 50-30-10 foot candle illumination standards (for work stations, work areas, and nonworking areas) shall be adhered to in the design of new lighting systems or alterations to existing systems, to the extent feasible. Where higher levels of illumination are determined to be necessary for specialized tasks, or for personnel safety or security reasons, they shall be provided. In these cases, however, the illumination levels should not exceed the applicable recommended levels of the Illuminating Engineering Society (IES), as contained in the latest edition of the IES Lighting Handbook, ANSI/IES RP1," Practice for Office Lighting," and ANSI/IES RP7," Practice for Industrial Lighting. Where higher illumination levels are required, consideration shall be given to providing local or task-supplemental lighting to minimize general overhead lighting requirements.

b. Fixtures.

(1) For general requirements, fixtures shall be of standard, high-efficiency commercial grade. Emphasis shall be placed on energy-efficient fixtures, selected on the bases of minimum life-cycle costs and satisfaction of visual task requirements. Proper consideration shall be given to glare and color rendition.

(2) For fixtures located in high value areas, and in exits, stairways, ramps, elevators, and landings, the diffusers and lenses shall be of noncombustible materials.

(3) For ballast lighting fixtures, the ballasts shall be UL listed, thermally protected, and shall conform to CBM-ETL (Certified Ballast Manufacturers-Electrical Testing Laboratory) requirements.

c. Exit Lighting. Exit and emergency lighting systems shall be provided in accordance with NFPA Code No. 101, "Safety to Life from Fire in Buildings and Structures." Special attention shall be given to emergency lighting requirements in windowless buildings.

7. GROUNDING. System and equipment grounding shall be in accordance with the National Electrical Code. The voltage difference between noncurrent-carrying metal parts and ground shall be essentially zero to minimize personnel hazards. Grounding conductors shall have adequate capacity to carry the maximum available fault current and be large enough to withstand possible physical and corrosive damage. Ground resistance should be as low as practicable and, in no case, exceed generally accepted values for the application. For reference, see IEEE Standard #142, "Recommended Practice for Grounding Industrial and Commercial Power Systems."

8. SYSTEM AND PERSONNEL PROTECTION.

a. System Protection.

(1) Circuit breakers, fuses, and related protection equipment shall be so selected, sized and sequenced in their operation as to limit damage to system components and power interruptions within the facility when abnormal conditions such as overloads, voltage surges, and electrical short circuits occur. The protection equipment shall have adequate load current capacities and adequate fault current interrupting ratings for the initial and projected loads and available short circuit currents. For design guidance, see IEEE Standard 242, "Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems", IEE Standard 141, "Recommended Practice for Electric Power Distribution for Industrial Plants", and IEEE Standard 241, "Recommended Practice for Electric Power Systems in Commercial Buildings."

(2) Where the available short circuit currents in new facilities will present problems that cannot be technically or economically resolved by the use of currently-available circuit breakers and switchgear, the use of short circuit current reducing methods such as those listed below shall be considered.

(a) Provide current-limiting fuses for general reduction of short circuit duty. Determine the maximum let-through current from the fuse characteristic curves, considering both light load and full load conditions. The effective value of the maximum current so determined will serve as the basis for determining the interrupting ratings of other protection equipment on the load side of the current-limiting fuses.

(b) Provide current-limiting reactors, high impedance busway, or obtain the additionally-needed impedance by the strategic selection of circuit lengths and cable sizes. The additional system voltage drops attendant with the use of these methods should be given proper consideration.

(c) For existing facilities, where the available short circuit currents have reached or exceed the interrupting ratings of installed protection equipment, consideration should be given to the feasibility of upgrading the existing equipment to increase their short circuit interrupting ratings or providing current-limiting fuses, or other features, as described above, before replacing the equipment.

(3) Requirements for ground fault protection, as well as overcurrent and phase-to-phase fault protection, should be considered. Article 230-95, "Ground Fault Protection of Equipment," of the National Electrical Code, requires that ground fault protection be provided for solidly grounded wye electrical services of more that 150 volts

to ground, but not exceeding 600 volts phase-to-phase, for each service disconnecting means rated 1000 amperes or more, with two listed exceptions. This requirement most specifically applies to 480Y/277-volt grounded systems. See Article 230-95 for this, and for other associated requirements that need to be satisfied where ground fault protection is provided.

b. Personnel Protection. In locations where the provision of electrical receptacles and use of low voltage equipment result in inherent personnel shock hazards from the possible line-to-ground passage of stray current through the human body, ground-fault circuit-interrupters (GFCI) shall be provided in accordance with the National Electrical Code and Occupational Safety and Health Standards (29 CFR Part 1910) at a minimum.

(1) These devices shall be UL listed and capable of detecting the passage of stray currents to ground and interrupt the circuit or circuits at sufficiently low milliampere levels and with sufficiently short millisecond interrupting time to protect human life.

(2) Particularly hazardous areas include those where electrical tools and appliances, electrical laboratory apparatus, or other fixed and portable electrical equipment are used, and where there is a probability of physical contact with fixed electrical ground points or surfaces by equipment operators. The most common are kitchen areas, bathrooms, laboratory areas, and other areas where installations of sinks, plumbing, laboratory benches, workbenches, and so forth, provide exposed electrical ground points and surfaces; and particularly in basement areas and wherever moist or wet conditions exist within buildings or in adjacent outside areas.

9. LIGHTNING PROTECTION. Criteria for lightning protection of buildings and other structures and protection of incoming power services, are contained in Chapter VII of this Order.

10. ENERGY CONSERVATION MEASURES. The following measures shall be given consideration and adopted wherever practical in the design and construction, or alteration, of electrical systems. This listing is not necessarily complete, and other electrical energy conservation methods that are determined to have safe and practical application should also be considered.

a. Use higher distribution voltages, consistent with code and other safety requirements.

b. Increase feeder and branch circuit conductor sizes, to reduce energy losses in service lines to utilization equipment.

c. Reduce the length of branch circuit runs by locating power distribution centers as close as practical to the loads.

d. Provide three-phase utilization equipment, rather than single-phase equipment.

e. Design for balanced loads in three-phase systems (and correct experienced unbalances during preoperational inspection and tests of new or altered facilities).

f. Design for an overall facility load power factor of 85 percent or higher. Provide capacitors on motors and other inductive loads that require power factor correction. Provide power factor controllers for motors with widely varying loads.

g. Size and select motors to match their shaft loads and to operate at their most efficient load points.

h. Design motor-driven equipment to start in an unloaded condition, to reduce starting power requirements. Two-speed motors should be considered for HVAC applications to reduce energy consumption during nonpeak or off-duty hours.

i. Provide higher voltage motors (e.g., 450-volt instead of 230 or 200-volt).

j. Provide high efficiency electric motors, and power and distribution transformers.

k. For lighting systems:

(1) Provide highly flexible manual/automatic switching systems that will permit turning off all unused or unnecessary lights. Consider connecting lighting system zones to a central supervisory control system where available.

(2) Install automatic photocontrols on lighting circuits which control interior lighting along exterior walls of facilities, where sunlight transmitted through high bay windows will provide ample illumination without artificial lighting. Automatic photocontrols should be set at 500 foot candles, outdoor exposure.

(3) Design for luminaire relocation flexibility to meet changing operating requirements, and evaluate use of low-voltage switching systems (24 volts or lower) for flexible switching capability.

(4) Provide high power factor ballasts (90 percent or greater) for fluorescent and other ballasted lighting units.

(5) Provide multi-level ballasts to permit varying lumen output for fixtures. Provide multi-level ballasts or properly sized ballasts necessary to safely add or remove lamps when tasks are changed in type or location.

(6) Provide the most efficient luminaires, lamps, and ballasts.

(7) Provide luminaires having fluorescent lamps with higher lumens-per-watt output, such as those listed below, after giving proper consideration to lamp life, and lamp and fixture costs.

(a) One 8-foot, 800 ma, high-output lamp instead of three 4-foot, 430 ma rapid-start lamps.

(b) One 4-foot rapid-start lamp or one U-tube lamp instead of two 2-foot preheat lamps.

(c) Reduced wattage lamps. Follow the manufacturer's recommendations in the application of reduced-wattage fluorescent lamps. Their operation is more sensitive to lower ambient temperatures (generally below 60° F), or where strong air drafts may blow directly on exposed lamps, than with the more standard fluorescent lamps. These reduced-wattage lamps have best application indoors, but even here, a night-time "set-back" of building temperatures below 60° F could adversely affect lamp starting and operation. However, before ruling out their use, proper consideration needs to be given to the net energy savings that might still be achieved with the use of these lamps. For example, while it may be necessary to increase building temperatures sooner (before daytime building occupancy) to assure proper lamp operation before the building is occupied, there may still be overall net savings in building energy use and energy costs.

(8) Design lighting for the tasks, and locate luminaires as directly over the task area as practical, within the limits of the luminaire supporting systems.

(9) Use higher lighting circuit voltages (e.g., 277-volt systems), together with low voltage (24-volt) switching systems.

(10) Provide more energy-efficient lamps (e.g., metal halide or high pressure sodium vapor). Note that in the application of high-intensity discharge (HID) lamps, such as high- or low-pressure sodium vapor and metal halide, it is important to keep in mind that people will not perceive color warnings and other safety-related information in these lighting environments in the same manner as under incandescent or flourescent lighting. These HID energy-conserving lamps do not have the same color-rendering properties as do some traditional but less-energy efficient light sources. While incandescent lamps emit energy throughout the visible region of the spectrum, and wave lengths produced result in easy recognition of the reds, greens, oranges, and blues, low-pressure sodium vapor lamps emit most of their energy in an extremely limited portion of the spectrum (i.e., yellow or yellow-orange light). Typical safety signs and other safety-related signs (excluding traffic signals or other signaling devices that have their own internal light sources which emit either red or green light) and posted information will appear quite different than under more conventional lighting environments. Significant personnel/ communication safety problems can result, and life safety of personnel and other operating safety requirements need to be fully considered,

when evaluating and selecting from these possible lighting alternatives. In addition, monochromatic light sources in the yellow range should not be a primary light source in continuously occupied areas requiring repetitive visual tasks, based on recently reported physiological problems associated with such use.

(11) Evaluate use of greater contrast between task lighting (work station) and background lighting (work area), such as 8-to-1 and 10-to-1, consistent with safety and operating requirements.

11. INFORMATION REQUIREMENTS FOR SYSTEMS OPERATION. The design contractor, construction contractor, or other designated party shall be required to prepare and deliver to the DOE construction contracting officer (or designee) final, "as-built," schematic and one-line electrical diagrams, load-flow and short circuit analyses, operating instructions, equipment descriptions, system and equipment load capacities, short-circuit interrupting ratings of protective devices; or other engineering information that will be required for system operation and maintenance purposes, as appropriate to the project. See Chapter I of this Order for additional operating and maintenance (O&M) data requirements.

CHAPTER VII

INTERIOR TELECOMMUNICATIONS AND ALARM SYSTEMS

1. COVERAGE.

   a. These criteria shall be applied in the planning and design of service entrances, cable riser and distribution systems, terminal and equipment closets, and similar facilities which prepare buildings to receive telecommunications and alarm systems employing wire lines. These systems include interior telephone, fire and security alarm and supervisory, intercom, paging, public address, warning and evacuation and miscellaneous other telecommunications and alarm services. These criteria do not apply to the design of telecommunications equipment or circuits, to wiring for temporary use of portable telecommunications and signal equipment, to conduit for instrumentation systems used to monitor, measure, or control process, production, or laboratory operations or building services by other than telecommunications and alarm means, or to automatic data processing equipment or electronic computers, except to the extent that such devices utilize telecommunications channels for electrical transmission purposes.

   b. For purposes of these criteria, cable riser and distribution systems include cable slots, sleeves, trays and racks; concealed and exposed conduits; floor-ducts, raceways and structural wireways; pull, junction, and outlet boxes; and terminal, splicing, and wiring cabinets.

2. CODES, STANDARDS, AND GUIDES. The latest editions of the codes, standards, and guides listed below shall be followed in designing supporting facilities for interior telecommunications and alarm systems:

   a. National Electrical Code, ANSI/NFPA-70.

   b. National Fire Protection Association (NFPA) National Fire Codes.

   c. National Electrical Manufacturers Association (NEMA) Standards.

   d. Underwriters Laboratories, Inc. (UL) Standards and "Product Directories."

   e. ANSI N2.3, "Immediate Evacuation Signal for Use in Industrial Installations Where Radiation Exposure May Occur."

   f. ANSI/ANS 8.3, "Criticality Accident Alarm Systems."

   g. American National Standards Institute (AMSI) Standards.

   h. "Intrusion Detection Systems Handbook," SAND 76-0554.

   i. Occupational Safety and Health Standards, 1910.165, "Employee Alarm Systems."

j. Factory Mutual (FM) "Approval Guide," and "FM Loss Prevention Data."

k. Documents useful in planning and designing supporting facilities for interior telephone systems include Department of Army TM 11-486-4, and -5, "Electrical Communications Systems-Engineering." Other similar planning aids are available on request from many telephone companies. Specifications covering interior security alarm systems will be found in the DOE "Intrusion Detection Systems Handbook," Volumes 1 and 2.

3. DOE DIRECTIVES. Other DOE directives to be followed in the planning and design of interior telecommunications and alarm systems include the latest editions and changes to those listed below:

a. DOE 5300 Series.

(1) DOE 5300.1A, TELECOMMUNICATIONS, of 11-16-81.

(2) DOE 5300.2A, TELECOMMUNICATIONS: EMISSION SECURITY (TEMPEST), of 8-30-82.

(3) DOE 5300.3A, TELECOMMUNICATIONS: COMMUNICATIONS SECURITY, of 12-7-83.

(4) DOE 5300.4, TELECOMMUNICATIONS: PROTECTED DISTRIBUTION SYSTEMS, of 10-28-81.

(5) DOE 5310.1A, TELECOMMUNICATIONS: DATA COMMUNICATIONS FACILITIES, SERVICES, AND EQUIPMENT, of 9-3-82.

(6) DOE 5320.1A, TELECOMMUNICATIONS: SPECTRUM DEPENDENT SERVICES, of 9-21-81.

(7) DOE 5330.1, TELECOMMUNICATIONS: TELEPHONE SERVICES, of 7-31-80.

b. DOE 5600 Series.

(1) DOE 5632.1, PHYSICAL PROTECTION OF CLASSIFIED MATTER, of 7-18-79.

(2) DOE 5632.2, PHYSICAL PROTECTION OF SPECIAL NUCLEAR MATERIALS, of 2-16-79.

4. DESIGN. Important factors in the design of interior telecommunications and alarm systems include:

a. Safety. Proper physical clearances or compartmentalization shall be provided from electric power conductors and other hazards. Minimum separations between telecommunications and signal conductors (and conduits), electric power condutors, and so forth, as set forth in the National Fire Codes should be exceeded where more stringent requirements are specified in other codes or standards in paragraph 2, above. Except where open wiring is permitted for temporary use or special circumstances, conduit or other enclosed wireways shall be installed to provide the necessary protection and facilitate installation, replacement, and extension of conductors. The National Electrical Code has certain prohibitions on use of open wiring (i.e., wiring not installed in metallic tubing, conduit, or raceway) in plenum ceiling spaces or other spaces used for environmental air. For reference see NEC Articles 300-22 and 800-3a, -3c, and -3d.

b. Flexibility. The size and arrangement of conduits, raceways, underfloor ducts, and terminal and equipment closets shall provide adequate flexibility and spare capacity to permit relocation, extension, and interconnection of telecommunications circuits. This requirement is primarily applicable to telephone service in administrative office areas. Some relocation of other telecommunications and alarm services, such as intercommunications stations and security alarm facilities, should be anticipated.

c. Accessibility. To facilitate access to telecommunication and alarm systems components for purpose of installation and maintenance, cable terminals and auxiliary station control equipment (such as line and lamp relays, power supplies, and so forth) should be located in closets or rooms outside regular working areas. Each closet and its contents shall be readily accessible, with adequate working space and clearance from all hazardous objects. Doors to equipment rooms, closets and cabinets shall be equipped with locks for access control.

d. Spare Capacity. The cable riser and distribution system and the terminal and equipment closets shall provide adequate spare capacity for increases in the circuit requirements of telecommunications station equipment and for the installation of new wireline services after initial occupancy.

e. Normal Power. Telecommunications and alarm facilities which provide emergency services, such as fire and security alarm, warning and evacuation systems, and essential telephone, teletype, and radio services shall be connected to the AC power service through separate disconnect facilities ahead of the main power disconnect device.

f. Emergency Power. Although many telecommunications and alarm systems employ central battery power during temporary interruption of the primary AC power service, certain tributary devices (such as ringing and busy lamps and line hold relays of key telephone instruments, smoke detectors, and so forth) depend upon local 120-volt AC power supplies. If a distributed emergency ac power service is not practicable, local wet-cell battery supplies anacinverters (converting DC power to AC power) shall be provided at telephone equipment closets and for vital alarm systems sensing devices.

g. Joint Use. Telephone circuits shall be used for other telecommunications and alarm services to the maximum extent practicable. Where separate conductors are necessary or justified, they should normally be routed through the main telecommunications and signal conduit system. Separate wireways and cabinets may be provided when necessary to meet security, technical or code requirements, or to effect significant economics in system costs.

h. Separation of Circuits. Adequate separation and isolation of telephone circuitry from electric power and control system wiring shall be provided to avoid noise interference and crosstalk.

i. Hazardous Locations. Telecommunications and alarm equipment and conductors shall be located outside hazardous areas whenever practicable. Areas considered particularly hazardous include locations subject to explosion, fire, flood, chemical fumes, excessive dust, radiation, or vibration and excessive electrical noise level. Where telecommunications and alarm services must be extended into hazardous areas special supporting facilities shall be provided, such as explosion-proof conduit and housings, acoustical treatment, shock mounts, shielding, and so forth to protect both the facilities and personnel.

j. Simplicity. Supporting facilities shall incorporate simplicity of layout, with special emphasis on locating the main telephone facilities for direct access from exterior service lines, and on ease of access to interior telephone station equipment and wireways.

k. Economy. Supporting facilities shall be designed to utilize standard competitive materials and components, of adequate size, gauge and quality, for economy in installation and use.

5. TELEPHONE FACILITIES. The initial and ultimate telephone requirements for each work area, floor, and building shall be determined in accordance with DOE 5330.1, TELECOMMUNICATIONS: TELEPHONE SERVICES. Supporting facilities should be designed in accordance with paragraph 4, above, and the following criteria. These criteria have particular application to office/administrative type buildings, but the design principles have application to other types of buildings as well.

a. Building Service Entrance.

(1) Where the outside telephone distribution cables are supported on pole lines, aerial entrance cable will normally be provided to the buildings. The type of building attachment required shall conform to the standards of the serving telephone company. Building anchorage and entrance sleeve may be provided by the Government or by the telephone company but shall, wherever possible, be installed during construction of the buildings.

(2) If future underground service is a reasonable assumption, at least two capped conduits or sleeves shall be provided through the basement wall at a below-grade depth as recommended by the serving telephone company. When a building will be served underground from

overhead distribution plant, conduit shall be provided from the building to a point two or three feet above ground level at the service pole. A spare capped conduit or sleeve shall be provided through the basement wall.

(3) In areas where the outside telephone plant is underground, at least two conduits and one spare shall be provided from the building to the nearest manhole.

4) Conduit shall be provided between the cable entrance location and the main distributing terminal to protect the cable from physical damage and electrical hazards. A 2 to 3 ft. space shall be provided between the entrance duct and the building conduits. The internal conduit shall be bonded to the building electrical ground. If the entrance duct is metallic, the local telephone company practice shall determine whether the entrance duct should be grounded or insulated. In areas subject to direct-current electrolysis, there should be no electrical continuity between cable sheaths and conduits in the building and those exterior to the building. The main distributing terminal should be located on the ground floor or higher and as near as practicable to the center of the building distribution system. For buildings served by a cable of 202 pairs or less, the main terminal may be wall mounted in a cabinet. For buildings requiring more than 202 pairs, a terminal room or closet shall be provided. The terminal area shall be accessible to telephone personnel at all times, be properly lighted, well-ventilated, and equipped with 120-volt AC duplex electrical outlets on a separate 20-ampere branch circuit. If the outside plant is aerial or subject to contact with high voltages, a protect terminal is required. In all cases, a suitable ground conductor (#6 AWG or larger stranded copper insulated wire) shall connect the building electrical ground to the terminal.

b. <u>Cable Riser and Distribution Conduits and Closets.</u>

(1) Telephone riser cables shall normally be extended from the main distributing terminal through conduits, sleeves, or shafts, to central distribution closets on various floors of the building. Wherever possible, risers shall be in vertical alignment with horizontal distribution of feeder cables confined to the basement or first floor level. Riser cables shall not be placed in elevator shafts.

(2) The central distributing terminals on each floor shall be mounted on racks or in wall-hung cabinets. These floor terminals shall be located in rooms or closets with adequate working space, lighting and ventilation and with provision for future growth. One duplex electrical outlet on a separate 20-ampere branch circuit will normally suffice at these terminals. If telephone relay or similar control equipment is to be located at the central distributing point, additional electrical outlets will be required on an emergency power source.

c. Station Control Equipment Closets or Cabinets.

(1) Telephone instruments that incorporate push buttons, indicator lamps, and so forth, require auxiliary relays and power supplies within close proximity to operate the control and indicating mechanisms. To consolidate the auxiliary relay and power apparatus, to minimize the requirement for electrical outlets required for its operation, to avoid obstruction of usable office space, and to facilitate access to the apparatus, these components should be located in telephone equipment closets zoned to serve 1,000-10,000 sq. ft. of usable office area. Shallow closets may be used to serve areas up to 4,000 sq. ft. A closet serving 1,000 sq. ft. shall have minimum dimensions of 18 in. in depth, 6 ft. 8 in. height, and 3 ft. in width. The width should be increased 1 ft. 6 in. for each additional 1,000 sq. ft. of floor area served. In areas of heavy communications density (over 10 lines per 1,000 sq. ft.), the shallow closet depth should be 24 in. to 30 in.

(2) Larger walk-in closets should be provided to serve 4,000-10,000 sq. ft. of floor area. Walk-in closets for 4,000 sq. ft. should be at least 4 ft. deep, 6 ft, 8 in. high, and 4 ft. wide. Additional lineal wall space of 1 ft. shall be provided for each additional 1,000 sq. ft. of floor area served. Where double doors are provided, center posts shall not be used. Walls on which equipment is to be mounted shall be prepared as required by telephone company standards. Not less than two 120-volt duplex receptacles on a separate 20 ampere circuit shall be provided in each closet. These receptacles shall be connected to the emergency power source, if available. If a central emergency power supply is not available and continuity of telephone service is essential, a rectifier-battery-inverter arrangement shall be provided to furnish local 120-volt AC power during interruptions of the normal power service. Telephone equipment closets shall be properly lighted, dry, well-ventilated, as dustproof as practicable, and free from excessive heat or vibration.

(3) Adjacent zone closets shall be interconnected with not less than two 1-1/2 in. conduits and each closet tied to its floor distributing closet with conduits sized as required by the telephone company. Where several telephone equipment closets are to be served by common conduit from the central distributing terminal, at least three 1-1/2 in. or larger conduits shall be provided between closets. Conduits should terminate in a protective bushing approximately 3 in. above floor level, or below ceiling if run overhead. Where zone closets are not practicable, floor standing cabinets with equivalent dimensions and features shall be provided. In areas where telephone instruments will not incorporate push buttons or indicator lamps, terminal cabinets sized to serve 1,200-1,500 sq. ft. of floor area may be substituted for the zone closets. Terminal cabinets should be similarly interconnected and tied by conduit to the appropriate central distributing terminal.

d. Station Conduit, Raceway, and Floor Duct.

(1) Wherever practicable, underfloor duct and baseboard raceway shall be specified to serve general office areas and other locations of high telephone density where relocation of partitions, furniture, and personnel are likely to occur. Where underfloor duct is not practicable, baseboard wireways or wall mounted raceways, installed flush if possible, shall be utilized. Aluminum conduit shall not be embedded in concrete. Underfloor duct runs should be spaced approximately 4.5 ft. on-center, with cross runs and junction boxes approximately every 20 ft. In addition to the cross runs, not less than three header ducts should be extended to zone equipment closets, with one header extended to the duct run nearest the perimeter wall.

(2) One square inch, minimum, of raceway capacity shall be provided for each telephone station, or for each 100 sq. ft. of floor area served. Underfloor duct shall be not less than 3 sq. in. in cross-section, incorporate riser points at not less than 30-in. centers, and shall be designed without offsets or bends. Risers or insets which restrict the cable opening to less than 1.9-inch diameter shall not be used. Normally, standard 2-inch pipe with an insulating top bushing will provide adequate riser capacity at minimum cost. Careful installation of underfloor ducts shall be specified to avoid entry of dirt, debris or concrete, and thorough cleaning after installation shall be required to remove obstruction and waste.

(3) In buildings to be served by two separate telephone sytems, duplicate riser and distribution conduits and terminal cabinets normally will be required. Terminal and equipment closets, underfloor ducts, raceways, and conduits serving station outlets normally will be shared by both systems.

e. Telephone Booths and Enclosures. Pay telephones with acoustic partitions or booths will normally be provided by the telephone company to serve employees and visitors. In large office buildings, recesses for one or more booths and directory shelf shall be provided at suitable locations in the corridors and at main points of entry for visitors. Telephone booths require 120-volt electric receptacle for lighting and ventilation. Interior booth recesses also require a lamp over the directory shelf. In industrial areas, space for telephone booths should be provided at suitable locations, such as cafeterias, change houses, lunchrooms, and so forth. Where official telephones will be located in areas subject to high noise levels, fully-enclosed or open-face booths should be provided.

f. Integral and Compatible Alarm Services.

(1) Many telecommunications and alarm services use telephone cable pairs in their operation and therefore do not require separate distribution facilities. These "integral" services include teletype, telegraph, facsimile, low-speed data, telephoto, telemetry, remote dictation

recording annunciator, code call, telautograph and other remote writing systems, master clock, radio remote control, and monitoring circuits of security alarm and supervisory systems. The initial and ultimate circuit requirements for these services shall be included in sizing the telephone cable riser and distribution system.

(2) Other telecommunications and alarm services require low resistance series circuits, employ high level audio signals or require broadband or radio frequency channels or special wiring which cannot be accommodated in the regular telephone cables, but which, under proper conditions, may share the same conduit system. These "compatible" services include fire alarm and supervisory; intrusion detection wiring; high-level intercom, paging, music distribution and public address; closed circuit television; radio and TV receiving; warning and evacuation horns or sirens; and highspeed data transmission facilities. Such services will normally require separate riser and feeder distribution conduits, boxes, and terminal cabinets. Joint use of conduits, equipment closets, underfloor ducts and raceway systems by telephone and other communications and signal conductors is permissible if the "other" conductors are shielded, transposed, or otherwise made electrically compatible; classified data or information is not being transmitted; and the working capacity of the conduit system is adequate to accommodate expected circuit requirements of all systems involved. The National Electrical Code contains specific prohibitions on mixing Class 2 or Class 3 power limited circuits in raceways with other circuits. For reference see NEC Articles 725, 800, and 810.

g. Temporary and Special Wiring. Exposed conduit, open cable trays and racks, and surface wireway may be used in areas where concealed wireways are not practicable, except that over-the-floor wireways shall not be used in new construction and their use should be avoided wherever possible in the revision of existing facilities. Where they must be used, suitable protection shall be provided to minimize the risks of personnel injury and damage to the wireways. Open (unprotected) wiring should be permitted only in structures provided for temporary use, such as construction offices or other temporary buildings or in areas requiring telephone service for very occasional and temporary periods.

6. FIRE ALARM AND SUPERVISORY FACILITIES. Fire alarm systems shall be designed in accordance with NFPA National Fire Code requirements. Supporting facilities shall be designed as described in paragraphs 4 and 5, above, and as follows:

a. Use of Telephone Facilities. For office buildings, administrative areas and, where applicable, for industrial plants, emergency reporting telephones (meeting NFPA Code requirements and listed by UL or approved by FM) may be provided instead of manual fire alarm pull boxes. Emergency telephones for interior use shall be located and marked in accordance with the rules for manual fire alarm boxes. Wherever practicable, emergency reporting telephones shall be installed in open-faced flush housings similar to the housings provided for elevator telephones. Emergency reporting telephones shall be connected through the regular telephone wireway system, except where separate conduit will result in significant economies or substantially greater reliability. For low occupancy areas, such as industrial occupancy areas equipped with a sprinkler system with a waterflow alarm to the fire department, consideration may be given to the use of the normal telephone system for reporting fires in lieu of providing manual fire alarm boxes or specified emergency telephones.

b. Distribution Conduit and Cabinets. Building entrance facilities shall be as specified for telephone entrance cable in paragraph 5, above. The main distributing terminal shall be located as near as practicable to the point of entrance and the terminal cabinet shall be connected to the building electrical ground. Although duct space in the telephone riser and distribution system may be allocated for fire alarm and supervisory cables, a separate conduit system is normally justified to minimize the length of alarm conductors and restrict access to alarm circuits. Cables of fire alarm and supervisory systems may, however, be extended through cabinets or closets serving communications systems provided the alarm cables are separated from other wiring and devices by conduit or partitioning or are distinctively color-coded and identified.

c. Power Services. Although many fire alarm and supervisory sensing devices are mechanically, hydraulically, or pneumatically actuated, certain devices are electrically powered from local AC power sources. Where the operation of such devices is essential during periods when regular power service may be interrupted, emergency power service shall be provided.

7. SECURITY ALARM AND SUPERVISORY FACILITIES. Interior security alarm and supervisory facilities include perimeter intrustion detection systems, protective alarms in vaults, rooms or areas or on safes and file cabinets, and watchman tour supervisory systems. In some systems, manually operated shunts on specific system parts are also electrically supervised. Conduit requirements for these systems shall be included in the design of new buildings and additions. Applicable requirements in DOE 5632.1, PHYSICAL PROTECTION OF CLASSIFIED MATTER, DOE 5632.2, PHYSICAL PROTECTION OF SPECIAL NUCLEAR MATERIALS and SAND 76-0554, "Intrusion Detection Systems Handbook," shall be followed and advice and guidance shall be obtained from cognizant DOE safeguards and security personnel during planning and design.

a. Use of Telephone Facilities. Security alarm systems of the central station type normally utilize a telephone cable pair between the central station console and each protected area or zone.

(1) Telephone conduit shall be extended into structural vaults during their construction to facilitate the provision of telephone or alarm service.

(2) Where the security alarm central station is located within the protected building, a separate branch conduit may be required between the alarm console or equipment rack and the nearest telephone terminal.

(3) Local security alarm systems will not usually require connection to the telephone system.

(4) Telephone cables and pairs used for alarm wiring shall not be marked in such a way as to indicate their use for such wiring; i.e., markers such as "pair number" may be used but the marker shall not be marked "alarm system" or by any other similar method.

(5) Alarm system telephone pairs may be wired through frame rooms but should not in any way be connected through switching equipment; i.e., these pairs must be dedicated direct pairs between the protected area and the annuciator location.

(6) Spare pairs should be made available for expansion of alarm zones and as available substitutes for deteriorated pairs.

b. <u>Alarm System Conduit</u>.

(1) Security alarm systems shall be designed in accordance with Volumes 1 and 2 of the "Intrusion Detection Systems Handbook," (SAND 76-0554) and direction from the cognizant DOE security personnel, including methods of alarm system wiring, use of concealed or exposed conduit or other raceway, and tamper indication features. Alarm wiring for windows to be protected by contacts or foil should be brought to a connection box at the mullion level of double sash windows or at the center/side of fixed panes. Exceptions may be required for casement windows and for special alarm arrangements.

(2) Alarm wiring for doors to be protected should be brought to a connection box adjacent to the upper hinge (for protective wiring on the door) and thence to a second flush box located over the door (for the door position detector).

(3) Watchman tour signaling systems normally consist of electrical transmitting stations at the start, midpoint, and end of each tour supplemented by nonwired mechanical stations designed to permit rearrangement by authorized personnel. In some instances, a system employing all electrical stations may be required. Since tour stations are wired in series and several tours may, in turn, be connected in series, conduit to the electrical stations shall be arranged accordingly. Conduit shall be aligned and sized to allow the circuits for each tour to be brought out at the alarm console to permit each tour to be individually tested and tours rearranged, if necessary. Where watch tour circuits extended to a fire alarm console for electrical supervision and recording of transmitted signals, conduits may bypass the security alarm console if permitted by

security criteria. The use of telephone circuits or telephone wireways is seldom suitable for watchman tour systems.

c. Power Services. Certain security alarm sensing devices require AC power. Where emergency power is available, security alarm system receptacles shall be connected to the emergency system.

8. INTERCOM, PAGING, AND PUBLIC ADDRESS FACILITIES. Requirements for intercom paging, and public address (including music distribution) systems shall be determined during facility planning. Design of supporting facilities shall be in accordance with paragraph 4, above, and as stipulated below.

a. Use of Telephone Facilities. Intercom paging, and public address facilities shall be furnished by the local telephone system where feasible. Where separate systems are found to be necessary or justified, telephone circuits shall be utilized to the maximum practicable extent.

(1) Dial code-call systems employing chimes (or horns for high-noise locations) may provide a paging service more economical than voice-operated systems.

(2) Where telephone circuits are to be used for intercom, paging, or public address systems, attention needs to be given to minimizing crosstalk interference on other telephone circuits. The peak distributed signal level should generally be limited to no greater than +2 decibels (dbm) as referenced to a zero dbm level of 1 milliwatt.

b. Conduits and Cabinets. Where separate conduits and cabinets for intercom, paging, or public address systems are required, they shall be located to avoid interference with other telecommunications and signal service, particularly crosstalk interference, and to provide adequate separation and shielding from power conductors and devices. An adequate number of properly dispersed medium-level transducers for paging and public address systems is preferable to a minimum number of high-level sources.

9. WARNING AND EVACUATION SYSTEMS.

a. Interior warning and evacuation signal systems normally employ horns or sirens supervised and controlled in a manner similar to a closed circuit fire alarm system. The system shall provide for local initiation and control of the warning and evacuation signals. Supporting facilities shall be similar to those described for fire alarm systems. For nuclear facilities, immediate evacuation signaling and criticality accident alarm systems shall meet the requirements of ANSI N2.3 and ANSI/ANS 8.3.

b. In multi-building plant areas the warning and evacuation systems within certain buildings may require interconnection to permit control from one or more remote locations. Remote control may be accomplished by landline or by radio.

(1) If landline control is provided, telephone circuits are normally used.

(2) If remote control by radio is provided, receiving equipment shall be located as close as possible to the antenna, to minimize line losses. The radio equipment may be unattended with output signals extended through telephone circuits to the local warning and emergency control center. Power for the radio equipment shall be provided from the emergency system.

c. Where buildings or plants receive warning signals from municipal, county, State, regional, or national warning centers, connections are normally by telephone line. Conduits permitting connections to offsite warning circuits shall be provided where required.

10. ENERGY MANAGEMENT SYSTEMS AND DEVICES.

a. In the planning and design of new interior telecommunications and alarm systems, or alterations or additions to existing systems, the need for energy monitoring systems and devices as a part of, expansion of, or in addition to such interior telecommunications and alarm systems shall be considered.

b. Criteria on energy management systems and devices are contained in Chapter XIII, of this Order.

11. OTHER TELECOMMUNICATIONS SYSTEMS. The initial and projected requirements for other telecommunications systems shall be determined in accordance with DOE 5300.1A, TELECOMMUNICATIONS. Supporting facilities shall be designed in accordance with paragraph 4 and paragraph 5f, above. Secure communications systems shall be in accordance with requirements contained in DOE 5300.3A, TELECOMMUNICATIONS: COMMUNICATIONS SECURITY. Other DOE Orders to be followed in planning and design of telecommunications systems include DOE 5300.2A, TELECOMMUNICATIONS: EMISSION SECURITY (TEMPEST); DOE 5300.4, TELECOMMUNICATIONS: PROTECTED DISTRIBUTION SYSTEMS; DOE 5310.1A, TELECOMMUNICATIONS: DATA COMMUNICATIONS FACILITIES, SERVICES, AND EQUIPMENT; and DOE 5320.1A, TELECOMMUNICATIONS: SPECTRUM DEPENDENT SERVICES.

12. INFORMATION REQUIREMENTS FOR SYSTEMS OPERATION. The design contractor, construction contractor, or other designated party shall be required to prepare and deliver to the DOE construction contracting officer (or designee) final, "as-built", schematic and one-line system diagrams, operating instructions, equipment descriptions and other engineering information that will be required for operation and maintenance purposes. See paragraph 3m in Chapter I of this Order for additional operating and maintenance data requirements.

CHAPTER VIII

EXTERIOR ELECTRICAL SYSTEMS

1. COVERAGE. These criteria shall be applied in the planning and the design of onsite electrical systems, including power supply lines, switching stations and substations, and exterior lighting systems. To the extent appropriate, the criteria shall be applied to the design of offsite power supply systems servicing DOE sites or facilities where design and construction are DOE-funded. These criteria are not intended to supersede, or in any way override more stringent electric power system design or construction criteria or standards that are developed and used by any of the Department's Power Administrations.

2. CODES, STANDARDS, AND GUIDES. In addition to the latest edition of the National Electric Code (ANSI/NFPA-70) and the National Electrical Safety Code (ANSI C2), the latest editions of codes, standards, and guides listed below shall also be followed:

   a. National Fire Protection Association (NFPA) National Fire Codes.

   b. National Electrical Manufacturers Association (NEMA) Standards.

   c. Institute of Electrical and Electronic Engineers (IEEE) Standards.

   d. Underwriters Laboratories, Inc. (UL) Standards and "Product Directories".

   e. Illuminating Engineering Society (IES) Lighting Handbook.

   f. American National Standards Institute (ANSI) Standards.

   g. Insulated Cable Engineers Association (ICEA) Standards.

   h. Edison Electric Institute (EEI) Standards.

   i. Department of Labor, "Occupational Safety and Health Standards," Title 29, Code of Federal Regulations, Part 1910.

   j. Factory Mutual (FM) "Approval Guide," and FM "Loss Prevention Data."

3. PLANNING. Planning of exterior electrical systems is necessary to assure that initial and projected power supply requirements will be satisfied, with regards to, quantity, quality and reliability. Safety, energy conservation, and operating and maintenance requirements should also be considered.

   a. Power Supply.

      (1) The individual maximum electrical loads of facilities to be served shall be used as components of the total project or area loads. Diversity between individual loads shall be evaluated and appropriate

diversity factors applied in determining the total estimated demand. Future area or project load growth shall be evaluated and applied in determining the power supply facilities' requirements.

(2) Unless required to assure power supply capability, achieve greater economy in power costs, or achieve greater required reliability, onsite central power generating stations shall not be provided instead of purchasing power from an available offsite utility company. Where an onsite central station is justified, it shall be designed in accordance with established utility industry practices.

(3) The quality and reliability of the power supply shall be evaluated against load requirements, with proper considerations given to voltage and frequency stability and service continuity.

(a) Where loads will require a high degree of voltage and frequency stability, the short-circuit capability (e.g., mVA. of short-circuit availability at the service connection point) and the stability of the supplying utility system shall be evaluated to assure that adequate power quality can be provided.

(b) Where alternate supply voltages are available (e.g., 230 kV, 115 kV, 13.8 kV), the minimum acceptable voltage level commensurate with adequate power supply capability and quality should be selected to minimize construction costs for power lines and voltage transformation stations.

(c) Critical area or facility loads should be served by separate and committed circuits. Where a high degree of service reliability is required for operating or safety reasons, two separate supply services shall be provided, physically separated and served from separate supply sources, to minimize the possibility of simultaneous service outages from natural or other causes. In lieu of providing two separate services, a single service supplied from a looped transmission or distribution system having adequate automatic or manual sectionalizing features may be adequate. In such cases, special attention will need to be given to the reliability of the single service.

(4) An overall load power factor of 85 percent or higher should be achieved. Capacitors on inductive loads, should be provided as near to the loads as practical.

(5) Details and costs of service connections, cost of service, provisions for metering, and operating and maintenance requirements and responsibilities shall be determined during negotiations with the supplying utility company. See Chapter I of this Order for additional requirements.

b. Emergency Power Supply. Onsite emergency standby power generating facilities may be provided to the extent necessary to satisfy health and safety requirements, security and safeguards requirements, or critical operating requirements.

4. SERVICE EQUIPMENT AND FACILITIES. Electrical supply facilities and overhead and underground power and communication services shall be designed and constructed in compliance with the National Electrical Safety Code, ANSI C2.

a. Power Supply Lines.

(1) Power supply lines shall be designed and constructed in accordance with established industry practices, such as those utilized by local utility companies, and existing conditions in adjacent areas and communities. Wood pole lines should be used where existing power supply lines are of similar construction or where installation is to be made in remote, unsettled, or industrial areas, and where power supply requirements can be adequately and economically satisfied thereby. Maximum utilization should be made of single-pole structures.

(2) When necessary to conform with local beautification programs, consideration should be given to the use of attractive line support structures, prior to installing transmission and distribution lines underground. See Chapter I of this Order for additional information.

(3) Joint use of poles, duct encasements and adjoining manholes for power and communications distribution shall maintain safety standards and limit electrical interference to a value which will result in satisfactory communications services. In the joint use of poles, either for multiple electrical distribution services or for both electrical and communications services, underbuilt lines or cables shall be of vertical construction. Exceptions by the use of double-stacked crossarm construction shall be permitted only where proper clearances for bucket-truck hot line maintenance work can be assured.

(4) Where congested areas, safety, service continuity, or conformance with good local practices dictate a need, primary and secondary power distribution circuits (cables) shall be placed underground.

(a) Underground distribution circuits may consist of direct buried cable installations or cable installed in duct. The use of less expensive direct buried cable and preformed manholes shall be given proper consideration before resorting to duct, reinforced concrete duct envelope, and manhole construction. The selection of one method over the other shall include life-cycle cost considerations, protection of underground cables from excavation or other damage, ease of cable replacement, provision for expansion, and circuit density. Generally, where there are requirements for several circuits and connections in a relatively small area or where service reliability is a prime consideration, cable in duct shall be used. Underground duct envelopes should be color-coded to facilitate identification, and electrical manholes shall be appropriately labeled.

(b) Direct buried cable should be used for single circuit installations through areas not likely to be disturbed by excavation and where service reliability is not of critical importance. Where the hazards exist, direct burial cable shall be protected from damage from burrowing animals by the use of cable with steel armor, or cables shall otherwise be installed in duct. Where direct burial cables are connected to above-surface junction or terminating boxes, they shall be encased in rigid steel conduit from the box to below ground level. Protective treated planks or precast reinforced concrete slabs should be placed above direct-buried cables. See Chapter I of this Order for additional criteria on underground services.

(5) Circuits, either overhead or underground, shall be arranged so that relatively unimportant circuits will not jeopardize important loads. Protective devices shall be provided and coordinated for sequential operation from the load to the source. However, the use of unnecessarily elaborate protection schemes shall be avoided.

(6) Industry "Preferred Standard" voltages shall be used, with a single voltage in any classification in order to minimize stocks of spare equipment required and to standardize operating and maintenance practices and procedures.

b. Switching Stations and Substations.

(1) Design shall be in accordance with established utility industry practices. When switching is the main function, circuit routings will dictate the station location. When transformation is the main function, the substations shall be located so that the lengths of secondary feederlines are kept to a practical minimum. Stations should generally be utilitarian in their design and construction. However, when necessary to conform with local beautification programs, consideration should be given to the use of low-profile switching station and substation structures and the provision of visual barriers at the perimeters.

(2) Where not otherwise provided for billing purposes by a supplying utility company, electric energy metering (kWH metering) should be provided at each substation of 500 kVA or larger capacity. In addition, when not required by the utility company, demand metering (kW metering) may also be provided for site or area load management purposes.

(3) Equipment layout shall provide adequate working space for routine testing and maintenance, replacement of equipment components, and operating flexibility. All equipment shall be clearly labeled. Safety signs and instructions shall be clearly posted.

(4) Grounding facilities, usually a buried, interconnected metallic grid, shall provide a low resistance to ground and a safe voltage gradient between all parts of the grounded system for all operating conditions. See IEEE Standard #142, "Recommended Practice for Grounding of Industrial and Commercial Power Systems," and IEEE Standard 80, "Guide for Safety in AC Substation Grounding" for additional information.

(5) Lightning and surge protection shall be provided in such a manner that the potential difference that can reasonably appear across the terminals of a protected device is adequately below the basic insulation level of the device.

(6) Substations or switching stations providing or distributing power to critical facilities shall be located within the protected site perimeter.

(7) Dikes and drainage provisions shall be made in transformer stations as required with regard to the local "Spill Prevention Control and Countermeasure Plan, in accordance with 40 CFR 112 regulations, "Oil Spill Prevention."

5. EXTERIOR LIGHTING.

a. Lighting system design for roadways, walkways, vehicle parking areas, and electrical switching stations and substations shall conform to applicable recommendations in the Illuminating Engineering Society (IES) Lighting Handbook, and ANSI/IES RP8, "Roadway Lighting."

b. Higher lumens-per-watt HID (High Intensity Discharge) lamps should be used wherever feasible (e.g., metal halide or high- or low-pressure sodium vapor lamps instead of incandescent lamps), for more effective lighting and for energy conservation. See paragraph 10k(10), page VI-16, Chapter VI of this Order.

c. Proper consideration shall be given to the use of higher voltage lighting systems (e.g., 480Y/277-volt instead of 208Y/120-volt or 240/120-volt) for greater system efficiencies.

d. Selective manual/automatic switching systems shall be provided for vehicle parking area lighting, wherever practical, to turn off all unnecessary lighting during inactive periods, consistent with safety and security requirements.

e. Design of protective lighting systems shall conform to applicable recommendations in the IES Lighting Handbook, and ANSI/IES RP10, "Practice for Protective Lighting." Protective lighting shall comply with DOE safeguards and security requirements for physical protection of property, classified matter and information, and special nuclear material. Special requirements shall be determined by consultation with cognizant safeguards and security personnel.

6. LIGHTNING PROTECTION.

a. Protection of Buildings and Structures. The need for lightning protection of buildings and other structures shall be determined from an analysis of such factors as the frequency of electrical storms, value of building contents, the height of buildings and structures in relation to their surroundings, hazards to personnel, and hazards related to the type of materials and equipment to be housed and operations to be performed. Generally, lightning protection systems should be provided for buildings and structures over 50 feet in height, exhaust stacks, towers, water tanks, and other tall structures; and for buildings containing facilities for the use, processing, and storage of radioactive, explosive, and other hazardous materials. However, it should be recognized that metal buildings and their contents may sometimes be made relatively lightning-proof by adequate grounding (to earth) and bonding of the metal covering, without recourse to more extensive overhead protection devices. Lightning protection systems shall be designed in accordance with the NFPA 78, "Lightning Protection Code."

b. Protection of Services. Proper attention shall be given to the provision of lightning protectors or other voltage surge limiting devices on incoming electric power and communications services to buildings and other facilities. This is particularly important for underground power cable services that are connected to overhead power distribution lines, to minimize the propagation of dangerous steep wave-front voltage surges.

7. INFORMATION REQUIREMENTS FOR SYSTEMS OPERATION. The design contractor, construction contractor, or other designated party shall be required to prepare and deliver to the DOE contracting officer (or designee), final "as-built" schematic and one-line electrical system diagrams and instructions for normal and emergency operating conditions, including normal voltage levels at all service points and substation buses; switching arrangements and operating instructions; equipment descriptions, load capacities, and short-circuit interrupting ratings; or other engineering information that will be required for system operation and maintenance purposes, as appropriate to the project. See Chapter I of this Order for additional operation and maintenance data requirements.

CHAPTER IX

EXTERIOR TELECOMMUNICATIONS AND ALARM SYSTEMS

1. COVERAGE. These criteria shall be applied in the planning and design of pole lines, cable trenches, underground ducts, manholes, handholes, and similar structures which guide and support exterior telecommunications and alarm cable and wire systems. Design criteria pertaining to radio, television and microwave towers and masts are contained in Chapter XXVI of this Order.

2. CODES, STANDARDS, AND GUIDES. The latest editions of the following codes, standards, and guides shall be followed in the design of supporting facilities for exterior telecommunications and alarm systems:

   a. National Fire Protection Association (NFPA) National Fire Codes.

   b. National Electrical Code, ANSI/NFPA 70.

   c. National Electrical Safety Code, ANSI C2.

   d. American National Standards Institute (ANSI) Standards.

   e. Bell System Practices (AT&T Co., Standards)-Plant Series (for plant leased from Bell Telephone System).

   f. National Electrical Manufacturers Association (NEMA) Standards; and ANSI/NEMA SB3, "Interconnection Circuitry of Noncoded Remote-Station Protective Signaling Systems: Signaling, Protection and Communications Apparatus."

   g. Department of the Army TM 11-486-4, and -5 "Electrical Communications Systems Engineering" (For other leased and government-owned plant).

   h. "Intrusion Detection Systems Handbook," SAND 76-0554.

   i. Factory Mutual (FM) "Approval Guide," and FM "Loss Prevention Data."

   j. Underwriters Laboratories, Inc. (UL) Standards and "Product Directories."

3. DOE DIRECTIVES. Other DOE directives to be followed in the planning and design of exterior telecommunications and alarm systems include the latest editions and changes to those listed below.

   a. DOE 5300.1A, TELECOMMUNICATIONS, of 11-16-81.

   b. DOE 5300.3A, TELECOMMUNICATIONS: COMMUNICATIONS SECURITY, of 12-7-83.

   c. DOE 5300.4, TELECOMMUNICATIONS: PROTECTED DISTRIBUTION SYSTEMS, of 10-28-81.

d. DOE 5330.1, TELECOMMUNICATIONS: TELEPHONE SERVICES, of 7-31-80.

e. DOE 5632.1, PHYSICAL PROTECTION OF CLASSIFIED MATTER, of 7-18-79.

f. DOE 5632.2, PHYSICAL PROTECTION OF SPECIAL NUCLEAR MATERIALS, of 2-16-79.

4. DESIGN. Important factors in the design of pole lines, trenches, and duct systems for telecommunications and alarm facilities include:

a. Definition of the areas and locations to be served and determination of their initial and ultimate requirements for telecommunications and alarm services.

b. Selection of the most direct and practicable routes consistent with existing installations, topography, site planning, and accessibility for construction and maintenance.

c. Determination of the type of construction to be used (i.e., aerial, direct burial, or underground duct) in accordance with service requirements, relative overall economy of the installed plant, and reliability.

d. Allowance of adequate capacity in overhead services, number and size of ducts, location and size of manholes, and so forth, to meet ultimate anticipated service requirements.

e. Determination of required locations for cable terminals, load coils, gas pressure points, alarm pull boxes, and so forth which may control pole spacing, manhole location, and so forth.

f. Adequate clearance from buildings, above ground, and travelways; adequate separation from electrical systems; and avoidance of hazardous locations.

g. Adherence to applicable limitations on length of pole spans and duct runs, and on number and radius of conduit bends.

h. Proper grading of pole lines and ducts, and adequate ventilation and drainage of manholes.

i. Proper sizing and guying of poles to meet applicable wind loading criteria.

j. Adequate grounding for lightning and power line protection.

k. Economy of construction and maintenance through use of standard, competitive materials and components of required size, strength, and quality.

l. Adherence to attenuation requirements for magnetic fields, electric fields, and plane waves for overhead pole lines and underground ducts containing conductors that carry classified data or information.

m. Maximum joint use of power-communications pole lines.

n. Color-coding of underground duct envelopes for identification, and aboveground cable routing markers for unencased underground duct runs and direct-buried cable. Markers shall not identify alarm cabling as such.

o. Where the hazards exist, direct burial cable shall be protected from damage from burrowing animals by the use of cable with steel armor, or cables shall otherwise be installed in duct.

p. Where direct burial cables are connected to above-surface junction or terminating boxes, they shall be encased in rigid steel conduit from the box to below ground level.

5. TELEPHONE LINES. Criteria for selection of telephone routes and design of pole lines, cable trenches, and duct systems shall conform to "Bell System Practices, Plant Series," for facilities leased from Bell Telephone Company, and to Department of Army TM 11-486-4, and -5 for facilities leased from an independent telephone company or for Federal Government-owned telephone plant.

6. FIRE ALARM AND SUPERVISORY SYSTEMS.

a. Outside cable plant for fire alarm and supervisory systems should normally be designed in accordance with the standards for telephone cable plant. In the joint use of poles for electrical power distribution and for supporting fire alarm and telephone cables, the fire alarm cable should be placed below the telephone cable for greater clearance from overhead power conductors and reduced hazards to alarm cable workers. Underbuilt cable runs shall be of vertical construction.

b. Fire alarm cables installed in underground ducts shall be distinctively marked within manholes and handholes shared with other communications cables.

c. Fire alarm pull boxes or emergency reporting telephones shall be installed in weatherproof housings manufactured specifically for the mechanism. Outdoor pull boxes and telephones should be mounted on buildings, posts, or pedestals rather than on line poles and should be served by underground conduit. See NFPA 1221, "Standard for the Installation, Maintenance, and Use of Public Fire Service Communications," Chapter 4, for additional requirements.

7. SECURITY ALARM AND SUPERVISORY SYSTEMS Where feasible, telephone outside plant should be used to provide security alarm and supervisory circuits between buildings and plants and to exterior alarm installations. Applicable requirements in DOE 5632.1, PHYSICAL PROTECTION OF CLASSIFIED MATTER, DOE 5632.2, PHYSICAL PROTECTION OF SPECIAL NUCLEAR MATERIALS, and SAND 76-0554, "Intrusion Detection Systems Handbook," shall be followed in the planning and design of these systems, incuding perimeter intrusion detection systems and

watchman tour stations. Advice and guidance shall be obtained from cognizant DOE safeguards and security personnel during system planning and design. Outside watchman tour systems normally consist of a minimum number of electrical transmitting stations and/or related nonwired mechanical stations. All exterior stations should be mounted in weatherproof housings specifically designed for the equipment. Watchman tour stations should be mounted on buildings, or on posts or stub poles not normally climbed by lineman. Marking light or banding identification is not normally required.

8. SECURE COMMUNICATIONS SYSTEMS. Secure systems shall be designed in accordance with appropriate requirements contained in DOE 5300.3A, "TELECOMMUNICATIONS: COMMUNICATIONS SECURITY, and DOE 5300.4, TELECOMMUNICATIONS: PROTECTED DISTRIBUTION SYSTEMS.

9. ENERGY MANAGEMENT SYSTEMS AND DEVICES.

   a. In the planning and design of new exterior telecommunications and alarm systems, or alterations or additions to existing systems, the need for energy monitoring systems and devices as a part of, expansion of, or in addition to such exterior telecommunications and alarm systems shall be considered.

   b. Criteria on energy management systems and devices are contained in Chapter XIII of this Order.

10. INFORMATION REQUIREMENTS FOR SYSTEMS OPERATION. The design contractor, construction contractor, or other designated party shall be required to prepare and deliver to the DOE construction contracting officer (or designee) final, "as-built," schematic and one-line system diagrams, operating instructions, equipment descriptions, and other engineering information that will be required for operation and maintenance purposes. See Chapter I of this Order for additional operating and maintenance O&M data requirements.