UNCLASSIFIED

HANFORD

STANDARD

DESIGN CRITERIA

HWS-10006

COPY NO._____

This book is the property of the Atomic Energy Commission. It is to be used for work on the Hanford Project and is assigned to the user named below, who is responsible and accountable for this book.

Upon termination of work or assignment on the Hanford Project, the user shall return this book to Engineering Files, 700 Area, to secure termination clearance.

Assigned to:_____________________

___________ 19_____

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

Reviewed and Approved for Public Release by the NSAT

Date

BEST AVAILABLE REPRODUCED COPY

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

REVISED 7-1-65
HANFORD PLANT STANDARDS PROGRAM

PREFACE

The policy, objectives, responsibilities, basic requirements, and operation of the Hanford Plant Standards Program are stated in AEC Manual Chapter RL 61R2 and Appendix 61R2.

Hanford Plant Standards are contained in the following books:

- **Mechanical Standards**
  - Mechanical Drawings and Specifications, and Welding Specifications
- **Guides**
  - Mechanical Guides
- **Electrical Standards**
  - Electrical Drawings, Specifications and Guides
- **Instrument Standards**
  - Instrument Drawings, Specifications and Guides
- **Architectural and Civil Standards**
  - Arch-Civil Drawings, Specifications and Guides
- **Design Criteria**
  - General and Specific Criteria for All Disciplines
- **Drafting Practice**
  - Standard Drafting Practices

Suggestions concerning the program are invited, and should be sent to the Standards Office of the on-site Architect-Engineer.
HANFORD PLANT STANDARDS
INDEX TO THE
DESIGN CRITERIA BOOK

Sections of Standard Design Criteria are listed by number and title in consecutive order.

GENERAL

SDC-1.1 Functional Design Criteria, Drawings, Specifications, ATP's, and CVI Files
SDC-1.2 Numbering Hanford Specifications - Referencing and Acquisition of Hanford and National Codes and Standards

ARCHITECTURAL-CIVIL
SDC-2.1 Architectural Design
SDC-3.1 Railroads
SDC-3.2 Minimum Depth of Underground Water Lines
SDC-4.1 Design Loads for Structures

MECHANICAL
SDC-5.1 Heating, Ventilating, and Air Conditioning

ELECTRICAL
SDC-7.2 Outside Lighting and Aerial Distribution
SDC-7.4 Underground Power Distribution
SDC-7.5 Interior Power and Lighting
SDC-7.7 Communication, Signaling, and Low-Voltage Control Systems
SDC-7.8 Fire Alarm Systems
SDC-7.10 Corrosion Protection

MISCELLANEOUS
SDC-9.1 Noise Control

Rév. 11-26-73

Design Criteria Book Index
This Page Only.
SDC-1.1

PREPARATION OF FUNCTIONAL DESIGN CRITERIA,
DRAWINGS, SPECIFICATIONS, ACCEPTANCE TEST PROCEDURES,
AND CERTIFIED VENDOR INFORMATION FILES

This Section consists of 18 pages.

Supersedes DI-SDC, DI-SDC-1.1 and DG-510-AC

<table>
<thead>
<tr>
<th>DESCRIPTION OF REVISION</th>
<th>HANFORD PLANT STANDARDS</th>
<th>NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rewritten</td>
<td>HANFORD - RICHLAND, WASHINGTON</td>
<td>SDC-1.1</td>
</tr>
<tr>
<td>PREP OR REV BY:</td>
<td>DESIGN CRITERIA:</td>
<td></td>
</tr>
<tr>
<td>HES/CSB</td>
<td>FUNCTIONAL DESIGN CRITERIA, DRAWINGS,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SPECIFICATIONS, ATP'S, AND CVI FILES</td>
<td></td>
</tr>
<tr>
<td>DATED:</td>
<td>REVISION:</td>
<td></td>
</tr>
<tr>
<td>11-26-73</td>
<td>G. Buchholz</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
STANDARD DESIGN CRITERIA

PREPARATION OF FUNCTIONAL DESIGN CRITERIA, DRAWINGS, SPECIFICATIONS, ACCEPTANCE TEST PROCEDURES AND CERTIFIED VENDOR INFORMATION FILES

This section establishes the general requirements for the design of facilities for Hanford and for the preparation of Project functional design criteria, drawings (including as-built drawings), construction and procurement specifications, acceptance test procedures (ATP), and Certified Vendor Information (CVI) files.

Central Engineering Files, Federal Building, Room 356, has custodial responsibility for all approved originals of drawings, HMS-numbered specifications (see SDC-1.2), ATP's and the CVI files for Hanford facilities. All such approved originals shall be sent to that location for permanent filing and storage. Two copies of CVI's are required for Central Engineering files.

References to the A-E in this Criteria include both on-site and off-site Architect-Engineers unless otherwise stated.

A. GENERAL DESIGN REQUIREMENTS

Preliminary and detailed design shall be in accordance with the following:

1. AEC Manual Chapter 6301, General Design Criteria.

2. AEC Manual Chapter 0550, Operational Safety Standards.

3. Other AEC Manual Chapter references as listed in Hanford Plant Standards Design Criteria SDC-1.2.

4. The Washington Industrial Safety and Health Act (WISHA), Safety and Health Standards, as supplemented by -
   a. The Occupational Safety and Health Administration (OSHA) Standards.
   b. Reactor Research and Development (RRD) Standards as applicable.
   c. Other safety requirements as dictated by experience and need.

5. Hanford Plant Standards, Specifications and Design Criteria as applicable.

B. PREPARATION OF PROJECT FUNCTIONAL DESIGN CRITERIA

1. The Functional Design Criteria is a summary description of new or improved systems, processes or facilities completely documenting the functional requirements; forming the basis for; and stating limitations governing design to assure a complete, safe and operable facility adequate for its intended purpose. Documentation shall include a description of the operational, physical, radiological and other essential design parameters, features, processes and characteristics, such as firm known maximum and/or...
minimum capacities, quantities, and tolerances, including the range of operating conditions, degree of reliability the facility must meet, and its intended useful life. Appropriate consideration should be given to the following:

a. Number of operating personnel, occupants, persons served, or extent of services provided.

b. Principal injury, fire, explosion and radiation risks, including exposure hazards to, as well as from, the proposed facility.

c. Radius or physical extent of service for communications systems.

d. Maintenance requirements, including remote maintenance and physical access requirements.

e. Physical security requirements.

f. Site location, including necessity for location in relation to other facilities. The site location must be compatible with the Master Plan for the area.

g. General and specific criteria and standards which the A-E must observe in the preparation of preliminary (Title I) design.

h. Applicable quality levels and the basic Quality Assurance philosophy for the project.

2. Unreasonably restrictive requirements should be avoided to permit design within the "state of the art", and for optimum construction costs.

3. Where ASME Pressure Vessel Code work is involved, all necessary information to comply with AEC-RL and the Operating Contractor's requirements shall be stated.

4. In those cases where the A-E's responsibility includes preparation of Acceptance Test Procedures or Procurement Specifications (may involve critical materials, engineered equipment, spare parts, etc.) or both, all pertinent requirements must be clearly described.

5. The effect of the completed facility on the environment shall be considered, and shall be in accordance with the policies of the AEC.

6. Non-technical and contractual items such as drawing submission schedules, construction cost estimates, manpower schedules and construction schedules, shall not be included in the project design criteria, but the necessary information should be transmitted to the AEC.
C. PREPARATION OF DRAWINGS

1. Drawings shall be prepared in accordance with the Hanford Plant Standards Drafting Practice Manual.

2. The A-E shall be informed of the project number and title.

3. Drawing numbers, drawing index numbers (see Drafting Practice DP-2-1) and building numbers (for new facilities) will be furnished by Central Engineering Files, Federal Building. The Operating Contractor's Project Manager shall obtain these numbers and transmit them to the A-E. A block of numbers can be reserved for large jobs.

4. Drawings shall be made on imprinted tracing film (see DP-1-0). A supply of tracing film will be furnished to off-site Architect-Engineers. For large jobs, the A-E may be permitted to order tracing film with the company name preprinted in the title block.

5. All final design drawings shall be signed by a licensed Professional Engineer.

6. Schematic drawings, one-line diagrams, flow diagrams, etc., shall be provided to show the system operation and for use in assembly, testing, start-up and operation.

7. The specified number of prints shall be sent to the Project Manager for review. After comments are resolved, the tracings shall be approved by the Project Manager.

D. AS-BUILT DRAWINGS

1. The original tracings shall be corrected and approved by the Project Manager after construction is complete to show the actual or "as-built" conditions and configuration. This work may be assigned to the A-E, or may be accomplished by the Operating Contractor. Details shall be taken from design and construction records and from field inspection. See Hanford Standard Drafting Practice DP-1-4 for detailed instructions for preparation of "as-built" drawings.

2. As-built tracings shall be delivered to Central Engineering Files, Federal Building, for permanent storage.

E. PREPARATION OF PROJECT SPECIFICATIONS

1. Construction specifications shall be prepared for project work. The required quality and type of materials, and the quality of workmanship, shall be clearly and concisely stated. Requirements should be the minimum consistent with the intended use.
E. PREPARATION OF PROJECT SPECIFICATIONS (Continued)

2. Appendix A of this Criteria consists of a modified Construction Specifications Institute (CSI) index for Hanford use; sample cover and approval, and contents pages; and a typical page of text for construction specifications. Construction and procurement specifications having a one-time use shall be numbered as described in SDC-1.2, i.e., the project or work order number is used.

3. Hanford Plant Standards and Specifications, where applicable, shall be incorporated by direct reference.

4. Federal, National and Hanford standards, specifications and codes for materials, equipment and workmanship referenced in each Section of the specification shall be listed by number and full title under the GENERAL heading of that Section (see sample page in Appendix A). Reference to the listed standards, specifications and codes in subsequent paragraphs of the Section shall be by number only.

5. In general, the specification should not restrict material or equipment to a single manufacturer. See Federal Procurement Regulations FPR1-1.305 through 1-1.307, and modifications to these regulations as contained in AEC Procurement Regulations 9-1.305-5 and 9-1.307, for use of Federal Specifications and "brand names".

6. Drawings and other information may be required during and after construction. For example, shop drawings prepared by the Seller are used for fabrication and erection. Data and drawings may also be required for operation and maintenance of the equipment. The A-E shall specify the essential drawings and information to be furnished, and shall determine what is needed for construction, tests, operations, and maintenance. Approved shop drawings may be required for files prior to construction. All file drawings shall be specified to be reproducibles or permanent copies.

7. Contractual subjects shall not be included in the specification. However, the A-E shall inform the Project Manager of all unusual items that should be included in the Special Conditions of the construction contract.

8. The specifications should not duplicate information shown on the drawings. Drawings should be used to show locations, dimensioned sizes, and arrangements.

9. When a specification is revised, the latest revision number and date are shown on the cover and approval page (see Appendix A), and the revision number is shown in the right hand margin opposite the change on each revised page.

10. A Table of Contents for a specification is not normally necessary where the specification is 10 pages or less in length.
E. PREPARATION OF PROJECT SPECIFICATIONS (Continued)

11. Procurement specifications shall be prepared for major and critical items of material and equipment. These specifications are attached to the Purchase Requisition and the Purchase Order, and become a part of the contract between the Buyer and Seller.

12. A formal procurement specification is generally not required where the technical information consists of three pages or less, in which case the requirements are written directly on the Purchase Order.

13. Procurement specifications may be either of the following two kinds or a combination of both.

   a. A performance specification states the technical requirements, and compliance is determined by the required performance. This usually includes capacity, functional features, characteristics, tests, etc., to satisfy operating conditions. The detail design, fabrication, and materials are left to the option of the Seller.

   b. A design specification states the technical requirements for the size, shape, materials, fabrication, and assembly which have been determined by prior design. Competent manufacturers or fabricators can produce the product from the specification and drawings submitted without the necessity of additional design.

14. It is advisable to prepare formal procurement specifications for the following, if for no other reason than to establish a permanent engineering record of the equipment.

   a. Engineered equipment, defined as any item purchased according to special predetermined design. This includes all items fabricated as specials.

   b. Manufacturer's stock items that are to be modified extensively, or which require special or unusual testing before acceptance.

   c. A system which is made up of many different parts combined into an operational unit.

   d. A product in which unusual hazards are involved.

   e. A product having a long lead time for procurement.

   f. A costly product.

   g. A product likely to be repurchased in the future.
F. **EQUIPMENT IDENTIFIED ON DRAWINGS BY EQUIPMENT PIECE NUMBERS (EPN)**

1. Equipment Piece Numbers (EPN) are used to identify special equipment. The Design Criteria shall indicate the items to be numbered and the corresponding EPN numbers. Procurement specifications are commonly prepared for EPN items. EPN numbers shall be shown on the approved drawings.

2. EPN numbers shall be furnished by the Operating Contractor.

3. The A-E shall specify that EPN numbers be applied as follows:
   a. Stencilled on the equipment with one-inch high letters and numerals using a permanent paint; or, on small equipment, where stencilling is impractical, letters and numerals shall be stamped on a metal tag, and securely fastened to the item.
   b. The letters EPN shall precede the number.

G. **PREPARATION OF ACCEPTANCE TEST PROCEDURES (ATP's)**

1. The specifications may require functional testing of the facilities and equipment after installation. An ATP is a detailed test procedure of the required tests and are normally prepared by the A-E. ATP's may include (but are not limited to) the following:
   a. Operating tests of valves, instruments, electric motors, automatic equipment, etc., to demonstrate that all components work freely, water flows, lights turn on, automatic equipment operates properly in response to the appropriate signal, etc.
   b. Heat runs on motors and motor driven equipment.
   c. Proper balancing of ventilating systems.
   d. Proper functioning of special equipment.

2. An ATP may cover a single item of equipment or may include an entire system of components.

3. Each ATP shall clearly establish the responsibilities for conduct, recording, witnessing, and approval of the test. The responsibility for furnishing and calibration of special test equipment, where required, shall be stated. See Appendix B for a sample ATP cover and approval page.

4. ATP's shall be numbered with the project or work order number plus a suffix similar to numbering of construction and procurement specifications as explained in SDC-1.2. For example, ATP's for Project WCP-732 would be numbered WCP-732-ATPl, 2, 3, etc.
H. PREPARATION OF CERTIFIED VENDOR INFORMATION FILES

1. A Certified Vendor Information (CVI) file is a compilation of manufacturer's data on major items of equipment. Two permanent copies of CVI data shall be specified to be furnished on the Purchase Order for Central Engineering Files, in addition to the number of copies required by the Operating Contractor.

2. The following order of assembly for CVI files is preferred.
   a. Manufacturer’s Specifications
   b. Drawings and Performance Data
   c. Installation Instructions
   d. Operating and Maintenance Instructions
   e. Material Certifications

3. Components (mechanical, electrical and instrumentation) of an integrated system should be cross-referenced.

4. Equipment shall be identified in CVI files by EPN number(s) where EPN numbers have been assigned.

5. Typical equipment for which CVI files are normally prepared is listed in Appendix C. Only applicable data shall be supplied. Superfluous material shall not be included in CVI files.
MODIFIED CONSTRUCTION SPECIFICATIONS INSTITUTE (CSI)

INDEX
FOR HANFORD PLANT WORK

DIVISION - 1 GENERAL REQUIREMENTS
/Documents prepared by the Commission.

DIVISION - 2 SITE WORK
Section 2A Site Clearing
Section 2B Earthwork
Section 2C Pile Foundations
Section 2D Site Drainage
Section 2E Site Work Concrete
Section 2F Landscaping
Section 2G Chain Link Fencing
Section 2H Railroad Work
Section 2I Demolition

DIVISION - 3 CONCRETE
Section 3A Concrete Work
Section 3B Precast Concrete
Section 3C Insulating Concrete

DIVISION - 4 MASONRY
Section 4A Concrete Block Work
Section 4B Brick Masonry

DIVISION - 5 METALS
Section 5A Structural Steel
Section 5B Steel Joists
Section 5C Metal Decking
Section 5D Miscellaneous Metals
Section 5E Architectural Metals

DIVISION - 6 CARPENTRY
Section 6A Carpentry

DIVISION - 7 MOISTURE PROTECTION
Section 7A Waterproofing and Dampproofing
Section 7B Built-Up Roofing
Section 7C Sheet Metal
Section 7D Caulking and Sealants

DIVISION - 8 DOORS, WINDOWS AND GLASS
Section 8A Hollow Metal Doors and Frames
Section 8B Blast Doors
Section 8C Sliding Metal Fire Doors
Section 8D Roll-Up Metal Doors
Section 8E Metal Windows
Section 8F Finish Hardware
Section 8G Glass and Glazing

Rev. 11-26-73
Appendix A

DIVISION - 9 FINISHES
Section 9A Lath and Plaster
Section 9B Gypsum Wallboard
Section 9C Ceramic and Quarry Tile
Section 9D Acoustical Treatment
Section 9E Ceiling Suspension System
Section 9F Resilient Flooring
Section 9G Painting

DIVISION - 10 SPECIALITIES
Section 10A Metal Toilet Partitions
Section 10B Toilet and Bath Accessories
Section 10C Chalkboards and Tackboards
Section 10D Metal Lockers
Section 10E Woven Wire Partitions
Section 10F Access Flooring

DIVISION - 11 EQUIPMENT
Section 11A Laboratory Equipment
Section 11B Loading Dock Equipment
Section 11C Audio Visual Equipment

DIVISION - 12 FURNISHINGS
Section 12A Metal Casework
Section 12B Blinds and Shades
Section 12C Furniture
Section 12D Rugs and Mats

DIVISION - 13 SPECIAL CONSTRUCTION
Section 13A Clean Room
Section 13B Instrumentation
Section 13C Prefabricated Buildings
Section 13D Radiation Protection
Section 13E Sound and Vibration Control

DIVISION - 14 CONVEYING SYSTEMS
Section 14A Dumbwaiters
Section 14B Elevators
Section 14C Hoists and Cranes

DIVISION - 15 MECHANICAL
Section 15A Heating, Ventilating and Air Conditioning
Section 15B Plumbing, Process and Service Piping
Section 15C Fire Protection Sprinkler System
Section 15D Building Pneumatic Leakage Test

DIVISION - 16 ELECTRICAL
Section 16A Electrical Work
Section 16B Fire Alarm System

Rev. 11-26-73
Appendix A

(Specification Number - See SDC-1.2)

CONSTRUCTION (PROCUREMENT) SPECIFICATION FOR

>Title Of Specification

>Title of Project

Original Issue Dated:  
Revision No. 1 Dated:  
Use Only Where a Specification is Revised.

Prepared By:

(Company name and address of A-E responsible for preparation of the specification)

Approved By:

(Company name of A-E responsible for preparation of the specification.)

(Company) Safety Eng'r Date (Company) QA Review Date

Approved for (Conformance to Design Criteria):
(Safety, Operability and Conformance to Title I):

(Department and Company Name of Operating Contractor Date

--SAMPLE-COVER-AND-APPROVAL-PAGE-FOR-SPECIFICATIONS--

Rev. 11-26-73 - 10 - SDC-1.1
(Specification Number)
CONSTRUCTION SPECIFICATION FOR
EVAPORATOR TRANSFER FACILITIES
FOR 241-S AND 241-SX TANK FARMS

---

~TABLE OF CONTENTS~

<table>
<thead>
<tr>
<th>Division No.</th>
<th>Title</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>General Requirements</td>
<td>1-1 thru 1-3</td>
</tr>
<tr>
<td>2</td>
<td>Site Work</td>
<td>2-1 thru 2-5</td>
</tr>
<tr>
<td>3</td>
<td>Concrete</td>
<td>3-1 thru 3-6</td>
</tr>
<tr>
<td>9</td>
<td>Finishes</td>
<td>9-1 thru 9-4</td>
</tr>
<tr>
<td>15</td>
<td>Mechanical</td>
<td>15-1 thru 15-8</td>
</tr>
<tr>
<td>16</td>
<td>Electrical</td>
<td>16-1 thru 16-7</td>
</tr>
</tbody>
</table>

(See CSI Index, Pages 8 and 9 of this Appendix for Division Numbers.)

---

SAMPLE TABLE OF CONTENTS PAGE FOR SPECIFICATIONS

Rev. 11-26-73
1. GENERAL

A. Scope: Furnish all labor, materials, equipment and services necessary to complete all earthwork, backfilling and grading work for structures and underground lines in connection with [name of project] as required by the drawings.

B. Referenced Standards and Specifications: The following listed standards and specifications form a part of this specification to the extent indicated by subsequent references.

(1) American Association of State Highway Officials (AASHO)

T180-70 Moisture - Density Relations of Soils Using a 10 Lb. Rammer and an 18 Inch Drop

T191 64 (R1968) Density of Soil In-Place by the Sand Cone Method

(2) Occupational Safety and Health Administration (OSHA)

Department of Labor
Federal Register
Volume 37, Number 243
Section 1926,652 - Specific Trenching Requirements

C. Submittals:

(1) The Contractor shall present to the Commission for approval the method he proposes to use to prevent overstressing the existing structure or interrupting service to existing facilities during excavation work. Commission approval of the method shall be obtained before any excavation is done within 25 feet of an underground line or structure.
<table>
<thead>
<tr>
<th>ACCEPTANCE TEST PROCEDURE NO.</th>
<th>REV. NO.</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUBJECT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BUILDING</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROJECT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROCEDURE PREPARED BY</td>
<td>(Company Name)</td>
<td></td>
</tr>
<tr>
<td>TEST PROCEDURE APPROVED</td>
<td></td>
<td>Date</td>
</tr>
<tr>
<td>(Company Names and Departments)</td>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>(Company Names and Departments)</td>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>(Company Names and Departments)</td>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>TEST PERFORMED BY</td>
<td></td>
<td>Date</td>
</tr>
<tr>
<td>(Construction) Operating) Contractor</td>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>TITLE III ENGINEER</td>
<td></td>
<td>Date</td>
</tr>
<tr>
<td>(Company Name)</td>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>TEST WITNESSED-BY</td>
<td></td>
<td>Date</td>
</tr>
<tr>
<td>(Company Names and Departments)</td>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>as Required)</td>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>as Required)</td>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>FINAL APPROVAL AND ACCEPTANCE</td>
<td></td>
<td>Date</td>
</tr>
<tr>
<td>(Company Names and Departments)</td>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>as Required)</td>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>as Required)</td>
<td>Date</td>
<td></td>
</tr>
</tbody>
</table>

---

SAMPLE OF COVER AND APPROVAL PAGE FOR AN ATP

Rev. 11-26-73
CHECK LIST FOR CONTENT OF  
CERTIFIED VENDOR INFORMATION (CVI) FILES

CVI files are usually required for the following equipment. Typical data for each item is included in the listing.

A. Mechanical Equipment*

1. Pumps and agitators
2. Compressors, turbines, and generators
3. Hydraulic equipment, including cylinders, valves, etc.
4. Steam generating equipment (boilers)
5. Rotary vacuum filters, material handling, centrifugals, crushers, mixers, separators, vibrators
6. Fire protection systems and equipment.
7. Engineered equipment.
   For each of the above:
   a. Assembly and component drawings
   b. Control and wiring diagrams including electrical drive characteristics and performance data (as applicable).
   c. Parts and spare parts lists.
   d. Maintenance and lubrication instructions (as applicable).
   e. Operating manual (as applicable).
   f. Installation instructions.
   g. Material certifications, welding procedures, etc.

B. Heating, Ventilation, and Air Conditioning Equipment*

1. Fans, blowers, roof exhaustors, and unit heaters
2. Coils and filters
3. Automatic control dampers and operators
4. Air conditioning units, including motors and exchangers
5. Humidifiers, de-humidifiers and air washers

*For instrument components, such as control, flow and pressure reducing valves, thermostats and controls, see "Instrument Equipment." For electrical requirements, see "Electrical Equipment." See also DG-114-M, Guide, Specifications for Mechanical Equipment", for additional CVI and Inspection requirements.
For each of the foregoing.

a. Assembly and component drawings (as applicable)
b. System and/or component control diagrams and performance data including motors ratings
c. Parts and spare parts lists
d. Maintenance and lubrication instructions
e. Installation instructions
f. Certification of compliance

C. Specialties and Optical Devices

1. Shielding Windows
   a. Assembly drawings
   b. Certification of light transmission
   c. Certification of glass densities
   d. Certification of irradiation test (Non-Browning)
   e. Installation and maintenance instructions

2. Periscopes
   a. Assembly drawings
   b. Spare parts lists
   c. Certificate of compliance
   d. Installation instructions

3. Mechanical Manipulators and Remote Handling Equipment
   a. Assembly drawings
   b. Spare parts lists
   c. Maintenance and lubrication manuals (as applicable).
   d. Installation instructions
   e. Wiring diagrams (as applicable)

D. Structural

1. Shielding Doors
   a. Assembly drawings
   b. Pneumatic or electrical operators and control diagrams
   c. Spare parts lists
   d. Welding procedures and certifications
   e. Certificate of compliance
2. Cranes, Hoists (motorized) and Elevators
   a. Assembly drawings
   b. Wiring and control diagrams
   c. Parts and spare parts lists
   d. Maintenance and lubrication instructions
   e. Clearance diagrams (as applicable)
   f. Installation instructions
   g. Complete material certification

3. Motor Operated Doors (non-shielding)
   a. Assembly and dimensional drawings
   b. Wiring and/or control diagrams
   c. Material certification
   d. Certificate of compliance

   For electrical motors, see "Electrical Equipment." CVI material is not required for reinforcing steel, building frame, or miscellaneous steel, doors, windows, partitions, siding, roofing, building hardware, building fittings, fixtures, etc.

E. Instrumentation
   1. Instrument components, including control panels and control systems
      a. Dimensional and assembly drawings
      b. Installation instructions
      c. Calibration and maintenance methods
      d. Circuit diagrams, schematics and component values
      e. Operating and testing guides
      f. Parts list and recommended spare parts lists
      g. Material certification

      Manufacturer's manuals or bulletins showing several models or items shall be marked for positive identification of the specific unit offered or furnished.

F. Electrical Equipment
   1. Unit Substations and Switchgear
      a. Wiring diagrams
      b. Performance data
      c. Installation and maintenance instructions
      d. Dimensioned outline drawings
      e. Parts lists
      f. Material certification
      g. Certificate of compliance
F. **Electrical Equipment** (Continued)

2. Voltage Regulators
   a. Wiring Diagrams
   b. Installation and maintenance instructions
   c. Performance data

3. Fire Alarm and Communication Systems
   a. Wiring and block diagrams
   b. Installation and maintenance instructions
   c. Parts lists, spare parts list
   d. Complete certification

4. Cathodic Protection Rectifiers
   a. Dimensioned outline drawings
   b. Wiring diagrams
   c. Installation and maintenance instructions
   d. Certificate of compliance

5. Transformers 50 kVA and Larger
   a. Dimensioned outline drawings
   b. Installation and maintenance instructions
   c. Performance data
   d. Parts lists, spare parts list
   e. Material certification
   f. Certificate of compliance

6. Motor Control and Lighting Panels
   a. Dimensional and arrangement drawings
   b. Wiring diagrams
   c. Installation and maintenance instructions
   d. Parts lists, spare parts list
   e. Performance data and curves
   f. Certificate of compliance

7. Motors - 3/4 hp and Larger
   a. Dimensional drawings
   b. Installation and maintenance instructions
   c. Performance data and curves
   d. Certification of compliance
F. Electrical Equipment (Continued)

8. Generators and Battery Chargers
   a. Dimensional drawings
   b. Wiring diagrams
   c. Installation and maintenance instructions
   d. Parts and spare parts lists
   e. Certificate of compliance

9. Lighting Units

10. Level and Pressure Switches

11. Solenoid Valves

12. Electrical Heating Units

   For Items 9 through 13:
   a. Dimensional drawings
   b. Installation and maintenance instructions
   c. Specifications and ratings
   d. Parts and spare parts lists
   e. Material certifications (as applicable)
   f. Certificate of compliance
   g. Performance curves and data

14. Solid State Power Controllers and Temperature Controls
   a. Dimensional drawings
   b. Wiring diagrams
   c. Installation and maintenance instructions
   d. Specifications and ratings
   e. Performance curves and data
SDC-1.2

STANDARD DESIGN CRITERIA

FOR

- NUMBERING HANFORD SPECIFICATIONS

- REFERENCING AND ACQUISITION OF HANFORD AND NATIONAL CODES AND STANDARDS

This Criteria consists of 3 pages.
A. NUMBERING OF HANFORD SPECIFICATIONS AND STANDARD SPECIFICATIONS

Specifications written for Hanford facilities comprise the following three categories:

1. Project or Work Order related specifications for a particular purpose having a one-time use.
   a. Project construction and procurement specifications shall be numbered with the project number plus a suffix. For example (Project WCP-732):
      - Construction specification: WCP-732-C1
      - Procurement specification: WCP-732-P1
      The second, third, etc., specifications would have the suffix C2, C3,---, or P2, P3,---.
   b. Specifications for work or procurement covered by a Work Order may be numbered using the Work Order designation, as above (AE-032-C1 or P1), or by other means as determined by the Project Manager.

2. Other Procurement Specifications
   Based on the Project Manager's best judgment, new procurement specifications having a potential for continuing use at Hanford shall be numbered with the HWS prefix (Hanford Works Specification), for example HWS-2197. Numbers are assigned by Engineering Files, Federal Building, Room 356. These specifications are filed at, and issued from, that location, and an IBM report listing all HWS specifications is distributed quarterly.

3. Hanford Plant Standard Specifications
   a. Standard specifications shall be numbered as follows:
      - Mechanical Standards: HPS-100 to 199-M
      - Welding Standards: HPS-200 to 299-W
      - Electrical Standards: HPS-300 to 399-E
      - Instrument Standards: HPS-400 to 499-I
      - Arch-Civil Standards: HPS-500 to 599-AC
b. Revisions to Hanford Plant Standards are numbered consecutively (1, 2, 3, ...). An original issue is Revision 0. Thus, a complete description of a Standard Specification would be HPS-321-E, Rev 3.

B. HANFORD STANDARDS

1. Hanford Standard Criteria - Drawings, Specifications, and Guides are contained in several volumes as shown on the Introduction page to each volume. Each volume includes an index to that volume only.

2. Hanford Standards books, or separate copies of any Hanford standard, are available from, and are issued to authorized personnel by Engineering Files, Federal Building, Room 356, by means of a properly executed Reproduction Order.

3. Use of Hanford standards should be by direct reference. They should not be copied or traced. Reference shall be by number, revision number, and title: for example, Hanford Standard AC-7-20, Rev 1, Railroad Crossing; except that the revision number shall not be included in construction specifications.

4. Requirements of national codes, standards, and specifications are in many cases modified, made more restrictive, or additional requirements imposed by Hanford standards. The letter or intent of the Hanford standards shall take precedence over any other code or standard. The Hanford Standard Guides contain generalized engineering information and are advisory only.

C. NATIONAL CODES AND STANDARDS

1. The National Bureau of Standards Miscellaneous Publication 288, Directory of United States Standardization Activities, is a complete listing and description of national organizations who contribute to the development of standards. It includes over 200 associations, societies, and agencies engaged in some form of engineering standards work.

2. A library of national standards is maintained in the Federal Building, Room 353, by the on-site Architect-Engineer. Standards publications, as well as various other handbooks, textbooks, and reference material, are available for loan or assignment to Hanford personnel. Catalogs and indexes to publications of most national standards organizations are maintained in the library. Standards material not in files and which pertains to Hanford interests will be procured promptly upon request.

3. References to national standards shall be made by number and title; for example, ASTM A53, Welded and Seamless
Steel Pipe. References to the American National Standards Institute shall be by full name, American National Standard C80.1-1966; or the abbreviation, ANSI C80.1-1966; to avoid confusion with the American Nuclear Society (ANS). If only selected parts of a standard are to be referenced, the specific chapters, sections, or paragraphs shall be clearly identified.

4. The latest edition of all codes and standards shall be used unless there is a particular reason for an earlier issue. However, the statement "latest revision" following a referenced standard shall not be used in specifications.

D. NATIONAL STANDARDS REFERENCED IN AEC MANUAL

1. The AEC Manual contains numerous references to national standards. Chapter Appendixes of particular importance to engineering design are as follows:
   a. Appendix 6301, General Design Criteria
   b. Appendix 0550, Operational Safety Standards
   c. RL Supplement 0550, Standards for Health, Safety, and Fire Protection
   d. Appendix 0270, Telecommunications Services Handbook
   e. Appendix 0510, Prevention, Control, and Abatement of Air and Water Pollution
   f. Appendix 2401, Physical Protection of Classified Matter and Information

      Security Handbook
      Annex A, Specifications for Interior Protective Alarm Equipment
      Exhibit 2, Protective Lighting Guides (Exterior)

2. As used in the AEC Manual with reference to national standards, the terms "basic", "prescribed", "shall be", and "must be", indicate that the requirements of the reference are mandatory as the minimum acceptable. The terms "recommended", "should be", and "may be", are recommended for adherence, or are to be used as acceptable guidelines.
SDC-2.1

STANDARD DESIGN CRITERIA

FOR

ARCHITECTURAL DESIGN
A. **SCOPE**

This Section of the Standard Design Criteria outlines the general architectural considerations applicable to structures designed for use at the Hanford Plant. See SDC-1.1 for general design requirements and SDC-4.1 for design loadings.

B. **BUILDING DESIGN**

1. **General**

   Selection of building type shall be based on the functional requirements of the building at the lowest cost compatible with sound construction methods. Costs for maintenance, operation and adequate protection from fire, safety and health hazards shall be considered.

   Generally, buildings having the least perimeter for the area enclosed have the greatest economy. A rectangular plan should be used unless a more costly arrangement can be justified. The plan should provide for maximum utility and flexibility. Design should provide for future expansion where it can be reasonably anticipated.

   Maximum building areas shall conform to provisions of the Uniform Building Code for the various types of construction and occupancy classifications. Where maximum limitations are specified in the Design Criteria for specific types of buildings, such limitations shall take precedence over Uniform Building Code requirements.

   Generally, manufactured items and construction materials should be of standard stock size and design with quality consistent with the life expectancy of the building.

2. **Planning and Layout**

   Space allocations should conform to sizes specified in the Design Criteria or indicated on the scope drawings.

   Usually, buildings should be one story. Multi-story buildings should only be used where land use, functional operation, or construction and maintenance economy can be justified. Basement spaces should not be provided unless an evaluation analysis shows functional or economic justification.

   Buildings should be designed on a modular unit basis so repetitive construction methods can be utilized. Modular unit dimensions should be compatible with occupancy and construction materials.
3. Framing

The structural system shall be selected with due consideration for functional requirements and economy. The type of constructions shall be as required by applicable codes and regulations for type of occupancy.

4. Floors

All floors should be of materials consistent with construction of the building, functional requirements, and in compliance with applicable codes.

First floor construction generally should be a monolithic concrete slab on undisturbed soil or, where necessary, on well compacted earth.

Floor live loads shall conform to SDC-4.1, Design Loads for Structures.

5. Foundations and Exterior Walls

Foundation footings shall be poured concrete. Foundation walls shall be either masonry or poured concrete.

Exterior building walls shall be materials which will give reasonable durability with minimum maintenance and construction cost. Consideration shall be given to use of concrete block or other masonry units, metal panels, precast concrete panels, or other prefabricated materials. Concrete walls, poured in place or tilt-up, may be used when advantageous or to meet a functional requirement. The use of combustible materials for exterior walls should be confined to buildings: (1) of low value, (2) of temporary construction, (3) which do not house important inventories or equipment, and (4) where there will be no undue hazards to personnel or adjacent structures.

Consideration should be given to use of control joints and other means to offset the tendency of masonry walls to crack. Attention should be directed to points where walls engage columns, where forces due to building frame expansion and settlement may exert unequal stresses, and other locations subject to cracking. See SDC-4.1 for seismic design.

6. Interior Walls and Partitions

In general, materials for interior bearing walls and permanent partitions shall have characteristics similar to the exterior walls to minimize differences in shrinkage and settlement.

Prefabricated movable partitions should be used where it is economically warranted because of the anticipated frequency of space arrangement.

Dry Wall type partitions shall be fire-rated.
7. Ceilings

Ceiling heights, or the underside of construction in all buildings, should be held to a minimum consistent with functional and operating requirements.

In warehouses, shops, and other industrial type buildings, the underside of overhead basic building material may serve as the ceiling for space below. However, suspended ceilings may be justified to simplify heating, ventilation, sanitation, lighting, fire protection, or contamination control.

In administration and laboratory buildings, consideration should be given to the choice of roof and overhead floor construction to eliminate the need for a separate finished ceiling. Overhead construction such as bar joists or wood joists should have finished ceilings to facilitate cleaning.

8. Roofs

Roofs should be constructed using repetitive bays. Dead level roofs shall be avoided. Parapets on exterior walls, canopies, and overhangs should be used only when they fulfill a functional requirement. Monitors and clerestories should be avoided except where they are combined with a need for high bay space. Access shall be provided to roof areas. Ladders shall generally be used except where frequency of access for maintenance or operation of roof mounted equipment justifies the need for stairways or where access other than ladders is required by building codes.

Asphalt roofing, roof insulation and vapor barriers are covered in the Hanford Plant Standards Roof Specifications (Arch-Civil book).

9. Roof Drainage and Flashing

The design of gutters and downspouts shall be based on a maximum rainfall of 2 inches per hour lasting for 5 minutes.

10. Windows, Doors, and Hardware

Fenestration should be planned to take full advantage of natural light and ventilation without undue imposition on heating and cooling loads. Windows and doors should be stock sizes and the industrial types should be used wherever practicable. Fixed windows should be considered for facilities equipped with year-round mechanical ventilation.

Weatherstripping should be provided on all exterior doors and movable windows. Fire doors shall conform to Underwriters' specifications and be properly labeled.

Double-acting doors and regularly used egress doors shall be provided with vision panels. Doors and windows shall be manually operated, except power operation may be provided for large or heavy doors requiring frequent operation, or special purpose doors and windows where manual operation is impracticable.
10. Windows, Doors, and Hardware (Continued)

Hardware should be plain and of a durable grade consistent with the life expectancy of the building.

Locksets shall be of design to accommodate a standard (1-1/8" nominal diameter) 5-pin cylinder, except that for installations in existing buildings, special 1-1/2" diameter or 6-pin cylinders may be required to match existing master key system. Specific master keying information for all lock cylinders and padlocks should be included in the Design Criteria for individual buildings.

Keys, lock cylinders, and padlocks shall be specified to be delivered by the manufacturer direct to the Security and Patrol Office.

Door closers shall be protected from the weather. Surface mounted closers may be considered where operating or head room clearances are inadequate.

11. Screens

Screens where required, generally should be the non-ferrous type, 18 mesh. Screens shall be readily removable or hinged to facilitate cleaning of windows. Screen frames should be of same material as window frames.

12. Sun Control

Sun control measures shall be considered for east, south, and west exposures for direct ray control and reduction of summer heat. Where provided, sun control measures shall be designed for latitude 46° 20' north.

13. Interior Finishes

Interior finishes shall be in keeping with the character of the building. Warehouses, shops, etc., generally should receive a more utilitarian treatment than would be provided for office buildings and laboratories.

The following items apply to all buildings:

(a) The use of vitreous tile on walls and ceilings generally should be avoided except in toilet and shower rooms. Tile wainscots should be limited to 4 feet high in toilet rooms and 6 feet high in shower rooms.

(b) The use of flammable materials should be avoided.

(c) Stairway treads and landings shall be provided with abrasive nosings in accordance with Hanford Plant Standard AC-2-1 and Instructions.
13. Interior Finishes (Continued)

(d) Concrete floors shall have a steel troweled finish (see Hanford Plant Standard Concrete Specifications), except exterior surfaces subject to traffic shall have a moderately rough surface-brushed, but not deeply grooved, (with a fiber bristle broom) finish.

(e) Interior and exterior floor surfaces periodically or continuously subjected to water or other solutions which create a slipping hazard, shall receive an anti-skid treatment.

(f) Floor, wall, and ceiling finishes will, in general, be included in the Design Criteria for the specific building. Finishes for concrete surfaces should be noted on the drawings.

14. Painting

Full advantage shall be taken of the natural finish of construction materials. For painting and painting procedures, see Hanford Plant Standards Guide DG-505-AC, General Building Painting.

15. Acoustical Treatment

The inherent sound absorption properties of ordinary building materials such as light weight masonry units should be utilized. Acoustical materials should be non-combustible.

Rooms which require wash down for contamination control normally do not lend themselves to acoustical treatment.

16. Insulation

Building insulation requirements shall be based on the outdoor design environment as shown in SDC-5.1, Design Criteria for Heating, Ventilating, and Air Conditioning. Other insulation requirements for special purpose occupancy shall be included in Design Criteria for the specific building.

Heating and cooling loads, and protection against deleterious condensation must be considered in selecting insulation. Insulation shall be non-combustible, and vermin and rot proof. It shall be provided with a vapor seal to prevent saturation of insulation, moisture damage to construction, and to avoid paint failure.

17. Termite Protection

Where wood construction is employed, the building site and surrounding area should be inspected for subterranean termites. Protection, where required, shall be in the form of reinforced concrete caps, metal shields, pressure treatment of lumber, and soil poisoning. Access to closed spaces for inspection shall be provided.
18. Waterproofing, Damp-Proofing and Drains

Properly designed basement walls, floors, or other facilities in contact with the ground, which are constructed of adequately dense concrete, usually will not require membrane waterproof protection from ground water.

Masonry walls below grade should be protected against leakage by means of cement pargeting, bituminous coatings, or other methods, where water penetration or dampness would be undesirable.

Subsoil drains around foundations normally will not be required. Should such a condition be encountered, the subsoil drainage shall not be connected to sanitary sewer lines.

19. Rest Room Facilities

The "Minimum Facilities" on the following page, although not complete, can be used to determine the minimum number of fixtures for most installations. Where buildings are divided into contaminated and non-contaminated zones, rest room facilities shall be provided for each. The use factor for each general zone area must be considered. Occupancy load when not specified in Design Criteria for a specific building shall conform to provisions of the Uniform Building Code.
MINIMUM FACILITIES

For Offices, Manufacturing Areas, Warehouses, Workshops and Similar Occupancies (1)

<table>
<thead>
<tr>
<th>Water Closets</th>
<th>Lavatories (2)</th>
<th>Urinals</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Persons</td>
<td>No. Fixtures</td>
<td>No. Persons</td>
</tr>
<tr>
<td>1-9</td>
<td>1</td>
<td>1-100</td>
</tr>
<tr>
<td>10-24</td>
<td>2</td>
<td>10 persons-</td>
</tr>
<tr>
<td>25-49</td>
<td>3</td>
<td>1 for each</td>
</tr>
<tr>
<td>50-74</td>
<td>4</td>
<td>additional</td>
</tr>
<tr>
<td>75-100</td>
<td>5</td>
<td>15 persons</td>
</tr>
<tr>
<td>1 for each</td>
<td>1</td>
<td>over 100 (3)</td>
</tr>
<tr>
<td>additional</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 persons</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

GENERAL:

Water Cooler (2): Bubbler type - 1 minimum for each 75 persons.
Showers: 1 for each 15 persons exposed to excessive heat or skin contamination.
Women's Lounge: A lounge space should be provided where women are working. The minimum space and lounge facilities should be as shown below:

<table>
<thead>
<tr>
<th>No. of Women</th>
<th>Space</th>
<th>Minimum Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-100</td>
<td>60 Sq. Ft. Min.</td>
<td>1 bed or couch</td>
</tr>
<tr>
<td>100-250</td>
<td>120 Sq. Ft. Min.</td>
<td>2 beds or couches</td>
</tr>
</tbody>
</table>

(1) The figures shown are based upon the number of persons indicated or any fractions thereof.

(2) Where there is exposure to skin contamination, provide 1 lavatory for each 5 persons.

(3) 24 lineal inches of wash sink or 18 inches of a circular basin, when provided with water outlets for such space, shall be considered equivalent to one lavatory.

(4) Water coolers or drinking fixtures shall not be installed in toilet rooms and shall not be installed in contamination control areas except under certain conditions such as when a radiation monitoring station is nearby and foot pedal operation is provided.

Revised 12-3-73
19. Rest Room Equipment: Each rest room shall be equipped as follows:

Toilet Compartments: Commercially available panel-type metal compartments, with in-swing doors, 32" minimum width for men and 34" minimum width for women. Doors shall be equipped with latch. Each compartment shall have a coat hanger and two-roll paper holders. In addition, each compartment for women shall have a metal purse shelf and sanitary napkin disposal.

Urinal Baffles: Baffles shall be used and shall match construction of toilet compartments.

Mirror Glass: Nominal size 16" x 20" with suitable backing and frame. The equivalent of one mirror shall be provided for each lavatory. Where practicable, mirrors in women's rest rooms should be placed in a location other than directly over lavatories.

Shelf: A five-inch deep metal shelf shall be provided above the lavatories.

Soap Dispenser: One for each lavatory. Dispensers shall be for granulated soap.

Waste Cans: One minimum and as required.

Paper Towel Dispenser: One for each lavatory. Dispensers shall be for single-fold interlocking paper towels 9-7/8" x 10-1/4" nominal size.

Sanitary Napkin Dispenser: One required in each women's rest room. Dispenser shall be of an approved type.

Entrance-Baffle: Each rest room shall be provided with a baffle to obstruct the view of the rest room.

20. Janitor's Closet

A minimum of one janitor's closet shall be provided for each building. In buildings separated into radioactive contaminated and noncontaminated zones, a minimum of one janitor's closet shall be provided for each zone. Equipment and fixtures shall consist of a deep janitor's sink, metal storage shelves, and hook strip for hanging mops, brooms, etc.

21. Lunch Room Facilities

Where lunch room facilities are required, they may serve employees within a single building or a group of buildings.

The lunch room shall not be located in any building or area where the lunch room is subject to radioactive contamination.
21. Lunch Room Facilities  (Continued)

Institution section tables (fixed seats) or circular tables usually require less unit space per person, and should be used wherever practicable. Square tables should only be used where periodic grouping of tables is a functional requirement.

Kitchen equipment may consist of cabinet sink, range, food warmer, refrigerator-freezer, water cooler, waste can, lunch box rack, coat rack. The size and quantity of each depends on the number of persons and operational arrangement. The design should provide for ease of expansion.

Chalkboards shall be provided in a lunch room serving also as a conference room.

Tables shall be metal construction with cigarette-proof plastic top. Chair frames shall be metal.

22. Locker Room and Shower Equipment

Lockers shall be standard size of steel construction with doors, clothes hooks, and hat shelf. Doors shall be louvered for ventilation and equipped with padlock eyes or with master keyed combination locks. Lockers shall be mounted on raised curbs. Generally, lockers should be equipped with sloping tops to simplify cleaning. Lockers shall be numbered as required. Lockers for street clothes should be 15" wide by 18" deep. For work clothes, a minimum size of 12" wide by 15" deep should be used. The height of lockers should be approximately 60" excluding curbs or legs. Single tier lockers should be used for street clothes.

Generally, benches should be provided for lockers. Bench tops shall be hardwood supported on metal pedestals firmly anchored to the floor.

Metal storage shelves shall be used for dispensing clean protective clothing. Bin fronts should be provided for rubber overshoes, canvas shoe covers, canvas boots, cloth hoods, caps, and gloves. The minimum depth for clean clothes storage bins should be 18 inches.

Laundry bag holders for soiled protective clothing shall be provided in conjunction with locker and shower rooms, and shall conform to Hanford Plant Standard AC-1-21.

23. Shower Rooms

Individual combination shower and dressing room compartments generally shall be provided only for women. For men, individual shower and dressing compartments should only be provided when justified by construction economy or operational requirements.
23. Shower Rooms (Continued)

Stall showers shall have a non-skid floor with a minimum compartment size of 32" by 32". Dressing compartments shall be equipped with seat, door with latch, and a minimum of three clothes hooks. Minimum size of dressing compartments shall be 32" by 36". Mildew and rot proof shower curtains shall be used. Shower doors shall not be used. Compartments shall be industrial type, baked enamel steel construction.

Shower heads for gang showers should not be spaced closer than 3'-6". Room widths should be a minimum of 10 feet when shower heads are located on opposite walls. A minimum room width of 6 feet should be used when shower heads are along one wall. Individual water control valves should be used. The temperature of hot water to the shower heads should be controlled so as not to exceed 135 F.

24. Platforms

Shipping and receiving facilities should be consolidated and centralized wherever practicable.

Truck bed height platforms should take full advantage of natural contours. For raised platforms on level sites, a properly drained, depressed access should be considered to obtain the required level.

Ramps should be provided when necessary for wheel traffic between platforms and floors of different levels.

Platforms shall be protected by bumpers. Bumpers may be commercial rubber type or wood conforming to Hanford Plant Standard AC-1-10, Loading Platform Bumper. Shipping entrances, truck entrances, downspouts, etc., exposed to damage by automotive and material handling equipment shall be protected by guard angles and wheel guards.

Access stairs generally should be provided at raised platforms.
SDC-3.1

STANDARD DESIGN CRITERIA

FOR

RAILROADS
A. SCOPE

These Design Criteria pertain to the requirements for construction of permanent and temporary railroads at the Hanford Project.

B. DESIGN STANDARDS

Design of railroad facilities shall be according to the latest issue of the manual on design and practices of the American Railway Engineering Association, these Criteria, and the following Hanford Standards. In case of conflict the Hanford Standards and Criteria shall govern.

- HPS-558-AC, Standard Specification for Railroad Construction and Instructions
- AC-4-50 & 52, Pipe Protection, Concrete Cradle Bedding and Encasement
- Section AC-7, Railroad Standards
- E-2-1, Horizontal Clearance, Utility Poles to Railroads
- E-2-5, Minimum Clearances from Overhead Wires to Grade and Buildings

C. TYPES OF CONSTRUCTION

1. Process and Mainline Tracks are tracks used for inter-area deliveries and operations process train movements.

2. Service Tracks are permanent tracks other than process or mainline.

3. Temporary Tracks are tracks for temporary use over short periods, including construction unloading tracks.

D. DESIGN REQUIREMENTS

1. Layout

Track layouts should be designed to provide flexibility and economy of operation for the service required. Construction trackage layout should fit, as nearly as possible, the final operational layout requirements to avoid duplication of track construction.

Process and mainline tracks shall be located and built to provide the greatest possible insurance, within reasonable economic limits, against derailment, overturn or collision of the process trains.
2. Materials
   a. Rail, ties, embankment, ballast, signs, etc., and track hardware such as ties plates, bolts, joint bars, rail anchors, gage rods, etc., for process, mainline and service track shall be as specified in Hanford Standard Specification HPS-558-AC, Railroad Construction.
   b. Where applicable, the following items should be called out on the drawings:
      1. Turnouts for process and mainline tracks shall be No. 10 in accordance with Hanford Standard AC-7-5, Turnout - 16'6" Switch and No. 10 Frog.
      2. Turnouts for service tracks, spurs, and yard tracks shall be No. 8 in accordance with Hanford Standard AC-7-4, Turnout - 15'0" Switch and No. 8 Frog.
      3. High switch stands (Racor 112-E or approved equal) shall be used on turnouts from the mainline. Low switch stands (Racor 36-D or approved equal) shall be used elsewhere.
   c. When specification HPS-558-AC is applied to temporary track, the accompanying specifications must state the following:
      1. New ties for temporary track shall be untreated Douglas Fir No. 2 Grade as produced and graded under the Grading and Dressing Rules No. 16 of the West Coast Lumber Inspection Bureau (WCLIB), minimum size 6" x 8" x 8'0".
      2. Tie plates shall not be installed on tangents of temporary track.
      3. Rail for temporary track shall be 70 lb or heavier section. Relay rail may be used.
      4. Turnouts for temporary tracks shall be No. 8 in accordance with Hanford Standard AC-7-4, Turnout - 15'0" Switch and No. 8 Frog.

3. Horizontal Alignment
   All horizontal curves shall be simple curves, without spirals. For process and mainline tracks, the minimum radius of curvature shall be 955.37 feet (6° curve). For service or temporary tracks, the minimum radius of curvature shall be 573.69 feet (10° curve). Broken back, compound, or reverse curves shall not be used.

   Superelevation shall be in accordance with the American Railway Engineering Association superelevation standards, according to the
expected speed of the trains. The amount of superelevation shall be shown on the drawings along with other curve data.

4. Grades and Vertical Curves

The maximum grade on process, mainline, or service track shall be 1% including compensation for curves which shall be at the rate of 0.04% per degree of curvature.

Parabolic vertical curves shall be used where the change in grade exceeds 0.2%. Minimum length of vertical curves shall be 20 feet for each 0.1% difference in grade.

5. Clearances

Clearances shall be in accordance with Hanford Standards AC-7-1, E-2-1, and E-2-5.

6. Crossings at Grade

Grade crossings shall be in accordance with Hanford Standards AC-7-20, Railroad Crossing, and AC-7-21, Wood Plank Railroad Crossing. For asphalt-paved roads, the bituminous crossing, AC-7-20, shall be used. Wherever possible, crossings should be at or near right angles.

7. Underground Pipe Crossings

Underground crossings of pipes carrying fluids which by their nature or pressure might cause damage if escaping under or in the vicinity of the track shall be encased. Refer to Hanford Standard DI-AC-4-50 and 52, Instructions for Use of Pipe Cradle and Encasement Standards, for detailed criteria on encasement.

8. Drainage

a. Adequate provision shall be made for drainage of the roadbed. Slope of drainage ditches shall be 1.0% minimum.

b. Consideration should be given to special requirements for drainage such as for borrow pits, and at grade crossings. The required finished slopes and ditches to accomplish such drainage shall be clearly shown on the drawings.

9. Cross-Sections

Cross-sections, and embankment and excavation slopes to be used shall be as shown on Hanford Standards AC-7-2, Railroad Cross-Sections, and AC-7-3, Widening at Railroad Turnouts.

10. Bridges

Design of railroad bridges should be in accordance with the Specifications for Railway Bridges of the American Railway Engineering Association. Design for live loads shall be for Cooper's E-80 loading.

Rev. 8-20-73

SDC-3.1
SDC-3.2

STANDARD DESIGN CRITERIA

FOR

MINIMUM DEPTH OF UNDERGROUND WATER LINES

This Section consists of one page only.
A. **SCOPE**

This Standard Design Criteria specifies the minimum depth of earth cover for underground water lines installed within the area of the Hanford Plant.

B. **MINIMUM DEPTH OF EARTH COVER**

1. **Frequent Flows**

   Where water in pipes and mains is frequently used, causing a regular flow in the line, the minimum earth cover above the top of pipe shall be 30 inches. Pipes and mains located under roads, streets, parking areas, or other locations where the earth cover will be well compacted, the minimum earth cover above top of pipe shall be 36 inches.

2. **Infrequent Flows**

   Where water in pipes and mains does not flow normally, or where water is infrequently used (dead end installations, pipe lines servicing safety showers, fire hydrants, etc.), the minimum earth cover above top of pipe shall be 42 inches.
This Section consists of 21 pages.

<table>
<thead>
<tr>
<th>DESCRIPTION OF REVISION</th>
<th>HANFORD PLANT STANDARDS</th>
<th>NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change paragraph D,</td>
<td>ARCH-CIVIL DESIGN CRITERIA</td>
<td>SDC - 4.1</td>
</tr>
<tr>
<td>page 3</td>
<td>DESIGN LOADS FOR STRUCTURES</td>
<td></td>
</tr>
<tr>
<td>PREP OR REV BY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HES/MD Byrd</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orig Issue Date</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-15-57</td>
<td></td>
<td></td>
</tr>
<tr>
<td>APPROVED BY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CS Bucholz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-25-74</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A. GENERAL DESIGN REQUIREMENTS

1. These criteria establish the design loads for all new, permanent facilities at Hanford, and to new additions or modifications of existing permanent facilities at Hanford. See Appendix A to this Design Criteria for application of seismic design requirements to additions or modifications of existing facilities.

2. Except as modified or amended by these criteria, the following codes and standards shall be used for design loads and for allowable unit stresses.

   a. General design requirements for buildings shall conform to the International Conference of Building Officials, Uniform Building Code (UBC). Dead loads, live loads, and roof loads shall be calculated in accordance with all requirements of Sections 2301 through 2308, inclusive.

   b. Concrete members and assemblies shall be designed according to the American Concrete Institute (ACI), 318 Building Code Requirements for Reinforced Concrete.

   c. Structural steel members and connections shall be designed in accordance with the American Institute of Steel Construction (AISC), Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings; and the American Welding Society (AWS), Standard D1.1, Structural Welding Code.

   d. Wood members shall be designed according to the National Forest Products Association, National Design Specification for Stress-Grade Lumber and Its Fastenings.

3. Classification of facilities for design purposes shall be as stated below.

   a. Facilities, systems, and structures at Hanford range from the ordinary utilitarian type to those which must remain functional during and after withstanding any credible natural phenomena or accident condition. Therefore, three categories of structures are established and defined in the following Sections B, C and D. Specific criteria for wind loading and earthquake ground motions are included for each category.
A. GENERAL DESIGN REQUIREMENTS (Continued)

b. For design purposes, it may be assumed that facilities of any category will not be subjected simultaneously to unusually high winds, seismic ground motion, accidents, or other site-related events (except normal operating conditions). The design shall include the load combinations given in Section K.

B. CATEGORY III FACILITIES

Category III structures, systems, and equipment are defined as those not vital to the safe shutdown of nuclear facilities, reactors or critical processing plants. Failure of Category III structures will not result in a release of radioactive, hazardous, or toxic materials. Such facilities include office buildings, warehouses, garages, shops, non-nuclear and non-sodium laboratories and test facilities.

1. Wind Loads

a. These facilities shall be designed in accordance with the UBC, Section 2308 and Tables No.23-F, 23-G and 23-H. Wind pressures as listed in Table 23-F under the wind-pressure-map area of 25 pounds per square foot shall be used for structures in normal semi-protected areas.

b. Design for higher wind pressures shall be considered for locations subject to unusual wind velocity such as the top of Rattlesnake Mountain where winds of approximately 160 mph have been recorded.

c. The Hanford area is subject to prolonged, straight and gusting winds prevalently from the west and southwest. Particular attention shall be given to adequate fastening of roof to walls and to details such as flashings, ventilators, access openings, louvers, etc.

d. For a comprehensive discussion of wind loading, see the American Society of Civil Engineers, Paper No. 3269, Wind Forces on Structures.

2. Earthquake Loads on Structures

Earthquake loads shall be calculated and design shall be in accordance with the UBC, Section 2314, for earthquake Zone 2, where applicable.

C. CATEGORY II FACILITIES

Category II structures, systems, piping and equipment are defined as those important to the normal operation of nuclear facilities, reactors or nuclear process plants. Category II facilities are not essential to the safe shutdown or isolation of nuclear facilities, and their failure could not result in a release of radioactive, hazardous, or toxic materials to the environs.
C. CATEGORY II FACILITIES

(Continued)

1. Wind Loads

The same criteria as required for Category III facilities shall be used.

2. Earthquake Loads

a. Structures shall be designed to withstand and remain operational under the forces produced by an Operating Basis Earthquake (OBE) having a maximum horizontal ground acceleration of 0.125 g, and a simultaneous maximum vertical ground acceleration equal to 2/3 of the horizontal. Structures shall be designed for earthquake forces superimposed on the normal design loads.

b. Facilities shall be designed for earthquake loads using a suitable dynamic analyses technique, such as the response spectrum or time history method. However, simplified design procedures may be used if they conservatively account for the dynamic behavior of Category II members and facilities during the postulated earthquake.

D. CATEGORY I FACILITIES

Category I facilities are defined as nuclear reactors, and structures for the storage of plutonium. The failure of such facilities might cause or increase the severity of a release of hazardous materials. Included in this category are those components and equipment vital to the safe shutdown of the Category I facilities.

1. Wind Loads - Tornado Conditions

a. These facilities shall be designed to withstand the effects of a tornado having a maximum tangential wind speed of 150 miles per hour (mph) plus a 25 mph translational wind speed (or a resultant wind speed of 175 mph) over the full height of the structure without loss of capability to contain any radioactive material or to perform their safety function. The wind force on the structure shall be calculated in accordance with ASCE Paper No. 3269.

b. These facilities shall be designed to withstand the negative pressure loading which results from a 0.75 psi ambient pressure decrease in three seconds, held for one second, and return to ambient at the same rate. Suitable allowances for venting and for structural components shielded from such ambient pressure changes may be made.
D. CATEGORY I FACILITIES (Continued)

c. The effects of tornado-generated missiles on these facilities shall be considered. Missiles may range from small debris, with up to maximum wind velocity, to massive low-velocity materials. Protection from penetration or crushing effects shall be provided. Investigation of the surrounding region for possible missile materials should be made. It has been determined that the following objects, traveling end-on at any height, could result from a 175 mph tornado.

1. Automobiles, railroad flatcars, and similar heavy compact objects would not become air-borne.

2. Design stress limits for the most severe combination of tornado and normal operating loads shall not exceed 90% of yield strength for reinforcing steel, and 75% of the ultimate strength of concrete. Design stress limits for the most severe combination of tornado loads, and normal operating loads, shall not exceed 90% of the yield strength of structural steel.

2. Earthquake Loads

a. These facilities shall be designed using accurate computational analyses, such as response spectrum or time-history analyses, which determine the dynamic response of the structures. They shall be designed for both the Safe Shutdown Earthquake (SSE) and the Operating Basis Earthquake (OBE). The structures shall be designed to assure a safe and orderly shutdown of the facility and the complete containment of fissile materials during and after withstanding the SSE or the OBE. The SSE produces a maximum horizontal ground acceleration of 0.25 g accompanied by a vertical acceleration of 2/3 the horizontal. The SSE Response Spectra, shown in Figure 2, shall be assumed to represent the SSE horizontal ground motions. The OBE produces a maximum horizontal ground acceleration of 0.125 g accompanied by a vertical acceleration of 2/3 the horizontal. The OBE Response Spectra, shown in Figure 1, shall be assumed to represent the OBE horizontal ground motions. Figures 1 and 2 are on pages 12 and 13.

b. Category I facilities shall be designed such that their response to the SSE earthquake ground motion shall be mainly elastic, although excursions into the plastic range are permissible provided that the safety and containment systems are not compromised.
E. ELEVATED STEEL WATER TANKS, STANDBIPES, AND RESERVOIRS

The design requirements of the American Water Works Association shall be used as the basis of design for elevated steel water tanks, standpipes, and reservoirs, except where special design is required for Category I or II structures.

F. CHIMNEYS AND STACKS

Design of concrete chimneys and stacks shall conform to ACI 307, Specification for the Design and Construction of Reinforced Concrete Chimneys, except where special design is required for Category I or II structures.

G. FOUNDATIONS AND RETAINING WALLS

1. Design of foundations and retaining walls shall, in general, be in accordance with the UBC, except where special design is required for Category I or II structures. Concrete design shall be according to ACI 318. Masonry design shall comply with the UBC, Chapter 24.

2. The minimum depth to the bottom of foundations of permanent structures (except elevated tanks and stacks) shall be 2'-6" below finish grade, except that footings shall bear on undisturbed earth, whichever is the greater depth. If it is not possible or practicable to place footings on undisturbed earth, footings and foundations may be placed on properly compacted backfill that has bearing capacity sufficient to meet design requirements.

3. The minimum depth to the bottom of foundations supporting elevated tanks and stacks shall be 4'-0" below finish grade, except that footings shall bear on undisturbed earth, whichever is the greater depth.

H. SOIL PRESSURES

1. The allowable soil pressure from Table No. 29-B, Chapter 29, of the UBC may be used for design of minor structures where precise soil bearing information is not available. These values are considered to be for undisturbed earth.

2. For major permanent structures, the subsurface soil and ground water conditions at the building site shall be determined by means of borings, test-pits, triaxial shear tests, or other approved field and laboratory methods.

3. The load table method of soil bearing testing is described in Appendix B to this Design Criteria. It may be used in special circumstances where the soil bearing is questionable or critical.
I. DESIGN LOADINGS

Structures, components, and systems shall be designed for the applicable service and special loadings as defined in this section.

1. Service Loadings

a. Dead (D) - Dead loads include the dead load of structures, equipment, piping, and any other permanently attached loads, static liquid loads (where applicable), weight of stored materials, and any other permanent static loads, such as vertical soil loads.

b. Live (L) - Live loads on structures, include operating floor loads, storage loads, movable loads such as cranes, fork lift trucks, etc., snow and ice loads. In accordance with ANSI A58.1, Building Code Requirements for Minimum Design Loads in Buildings and Other Structures, uniformly distributed roof loads shall be assumed for ice or snow consistent with the site selection. Consideration shall be given to the geometry of the roof system and to temporary increased loading due to local pocketing of snow or personnel traffic on the roof.

c. Thermal (H) - Thermal loads are loads which develop from temperature changes. Such loads shall include those due to thermal expansion or contraction of piping and vessels and temperature gradients through walls.

d. Pressure (P) - Pressure loads include loads due to the pressure of gases and liquids.

e. Wind (W) - The 100-year wind shall be used with gust factor as specified in ASCE 3269. For Richland, W = 67 mph. The wind load or design pressure due to maximum wind velocity shall be computed according to ASCE 3269.

f. Earthquake (Ea) - The Operating Basis Earthquake (OBE), and associated vibratory ground motion, is a condition which might reasonably be expected to occur during the operating life of the plant and during which those structures, systems, and components necessary for plant safety and operation are designed to remain operable. The design response spectra shall be as shown in Figure 1, page 12. For the Hanford site $E_0 = 0.125$ g horizontal; 0.083 g vertical. Appropriate damping factors are given in the material tabulated on page 7.

NOTE: Seismic design for Category III elements may be in accordance with Uniform Building Code with earthquake loads based on the Earthquake Zone specified (i.e., Seismic Zone 2).
I. DESIGN LOADINGS (Continued)

g. Lateral Earth Pressure (Q) - Lateral earth pressure shall include both the static earth pressure loads due to the retaining wall effect on the structure (Categories I, II, and III) and the dynamic earth pressure loads due to earthquake (Categories I and II only). The specific values shall be based on results of foundation and soils study of the site.

2. Special Conditions

a. Earthquake (Eg) - The Safe Shutdown Earthquake (SSE), and associated vibratory ground motion, is a condition which represents the maximum credible earthquake for the site. Structures and systems critical to nuclear safety (Category I) are designed to withstand the SSE and remain operable.

1. Design loads, stresses, and displacements resulting from the established SSE ground accelerations shall be determined for all Category I structures by dynamic analyses.

2. SSE Design Response Spectra shall be as shown in Figure 2. The SSE for the Hanford site shall be 0.25 g (horizontal) and 0.17 g (vertical) at zero period.

3. The following damping factors shall be the maximum used for dynamic analyses:

<table>
<thead>
<tr>
<th>Type of Structure</th>
<th>% of Critical Damping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel Containment Structures</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
</tr>
<tr>
<td>Concrete shear wall buildings</td>
<td>5.0</td>
</tr>
<tr>
<td>considered as a whole and</td>
<td>9.0</td>
</tr>
<tr>
<td>soil supported</td>
<td></td>
</tr>
<tr>
<td>Individual concrete shear walls</td>
<td>2.0</td>
</tr>
<tr>
<td>and elements</td>
<td>5.0</td>
</tr>
<tr>
<td>Welded Steel</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
</tr>
<tr>
<td>Bolted or riveted steel</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
</tr>
<tr>
<td>Flexible equipment, piping and steel</td>
<td>1.0</td>
</tr>
<tr>
<td>supporting systems</td>
<td>2.0</td>
</tr>
<tr>
<td>Rigid, equipment and systems</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td>Foundation materials</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>7.0</td>
</tr>
</tbody>
</table>

4. For soil-supported structures, the dynamic analyses shall include the effects of vertical and horizontal soil springs on the computed response.
J. LOADS APPLICABLE TO DESIGN CATEGORIES

The various categories of structures shall be designed for the loads shown below as applicable.

1. Service Loadings

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Category I</th>
<th>Category II</th>
<th>Category III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dead</td>
<td>D</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Live</td>
<td>L</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Thermal</td>
<td>H</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Wind</td>
<td>W</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Pressure</td>
<td>P</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Earthquake (OBE)</td>
<td>E₀</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Earthquake (UBC)</td>
<td>Eₚ</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Lateral Earth Pressure</td>
<td>Q</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

2. Special Conditions

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Category I</th>
<th>Category II</th>
<th>Category III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earthquake (SSE)</td>
<td>E₀</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Tornado</td>
<td>-</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

K. LOAD COMBINATIONS AND ALLOWABLE STRESSES

Structures shall be designed for various loads and loading combinations using the Ultimate Strength Method for Category I and Category II concrete; the Working Stress Method may be used for Category III concrete. The load factors and capacity factors shall be based on applicable industry codes for concrete and structural steel. Concrete structures shall be proportioned for ductile behavior; i.e., with steel stress controlling the design. All of the load combinations and allowable stresses in this and the following subsections shall be reviewed prior to the start of detailed design, based on the status of this evolving technology at that time. Equipment and piping shall be designed to resist the various loads and load combinations using design and analytical methods, allowable stresses, and non-destructive testing methods established in applicable codes. Code references for equipment and piping include the words "as applicable" to indicate the intended usage of the codes as described below.
K. LOAD COMBINATIONS AND ALLOWABLE STRESSES (Continued)

1. Category I Structures
   a. Service Loads

   (1) The design of Category I structures shall satisfy the most severe of the load combinations shown below:

   \[
   D + L + H + P + Q \\
   D + L + H + P + Q + E_o \\
   D + L + H + P + Q + W
   \]

   (2) Load factors and capacity factors for concrete shall be in accordance with ANSI A89.1 except that for earthquake and wind loadings the required strength \( U \) shall be computed as

   \[
   U = (1.4D + 1.7L + 1.7W) \cdot 0.75 \\
   U = \left[1.4D + 1.7L + 1.7 (1.1 \times E_o)\right] \cdot 0.75
   \]

   where live load (L) is the specific live load applicable during wind or OBE.

   (3) For structural steel, the allowable stresses shall be as shown in the AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings, except that AISC permitted increases in stress for short duration loads shall not be used when designing for wind or OBE loadings.

   b. Special Conditions

   (1) For load combinations during Special Conditions, Category I structures shall in general be proportioned to maintain elastic behavior. The upper limit of elastic behavior is considered to be the yield strength of the effective load-carrying structural materials. The allowable stress for steel (including reinforcing steel) shall be 0.9 \( F_y \). The yield stress for reinforced concrete structures is considered to be the ultimate resisting capacity per ANSI A89.1. The design of Category I structures shall satisfy the most severe of the loading combinations shown below:

<table>
<thead>
<tr>
<th>Load Combinations</th>
<th>Stress Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( D + L + H + P + Q )</td>
<td>75% of 0.85 ( f_c ) for concrete; 90% of yield stress in steel</td>
</tr>
</tbody>
</table>

   (2) The load factors for concrete in the case of SSE (\( E_U \)) shall be as follows:

   \[
   U = 1.1 \ (D + L + H + E_D)
   \]
K. LOAD COMBINATIONS AND ALLOWABLE STRESSES (Continued)

(3) Any increases in lateral earth pressure (Q) and vessel liquid pressure (P) due to SSE shall be included in \( E_D \) in the above equations.

2. Category II Structures

Category II structures shall be designed according to Section Kl.a (Service Loads).

3. Category III Structures

Category III structures shall be designed according to the applicable standard building codes. Concrete and steel structures shall satisfy the most severe of the following loading combinations without exceeding the specified stresses.

<table>
<thead>
<tr>
<th>Load Combinations</th>
<th>Stress Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( D + L + H + P + Q )</td>
<td>Reinforced Concrete: ACI 318 ultimate resisting capacities</td>
</tr>
<tr>
<td>( D + L + H + P + Q + E_u )</td>
<td>Structural Steel: AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings</td>
</tr>
<tr>
<td>( D + L + H + P + Q + W )</td>
<td></td>
</tr>
</tbody>
</table>

Reinforced concrete structures shall be designed for ductile behavior in accordance with the applicable requirements of ACI 318 with load factors for \( E \) and \( W \) as modified in the foregoing Section Kl.a.

4. Category I Equipment

Loading combinations (as applicable) used to design all Category I equipment shall be analogous to those specified for Category I structures. The seismic effects for all Category I equipment shall be handled by specifying the response spectrum at their mounting points. Such spectra will be derived from the seismic analyses of the structure containing the equipment. Fiberglass-reinforced plastic pressure vessels shall be designed, installed and tested in accordance with ASME Section : as applicable. The seismic analysis of Category I equipment shall be based on one of the following three methods depending on the relative rigidity of the equipment being analyzed.

a. Equipment which is rigid (structures with periods of approximately 0.05 sec or less) and rigidly attached to the supporting structure shall be statically analyzed. The horizontal and vertical static forces, g factor, used shall equal the horizontal and vertical earthquake excitation based on the acceleration of the supporting structure at the appropriate elevation.
K. LOAD COMBINATIONS AND ALLOWABLE STRESSES (Continued)

b. Equipment which is not rigid (period greater than 0.05 sec), may be idealized for analysis as a single-degree-of-freedom system, and then statically analyzed for response to the peak of the appropriate damped floor response curve. This approach cannot be under conservative; and if the results would require significant added cost for equipment or its supports, the method in the following paragraph c. should be used.

c. Dynamic analyses of non-rigid equipment may be performed using multi-degree-of-freedom idealizations. The analyses shall include the effect of model participation factors and mode shapes together with the spectral motion of the floor response spectrum defined at the support of the equipment. A sufficient number of masses shall be included in the mathematical model to insure that coupling effects of members within the component are properly considered. The inertial forces, moments and stresses shall be determined using a reasonable number of modes and then summed using a procedure such as the square root-sum-of-the-squares method. The number and shape of the modes used in the calculations shall represent in a practical manner the dynamic response of the equipment.

5. Category II and III Equipment (Including Vessels)

Standard acceptable design practices shall be used unless modifications are required to meet other specified criteria presented in other sections for equipment or systems. Loading combinations (as applicable) shall be analogous to those specified for Category II and III structures. The design of Category II pumps and valves shall meet the requirements of ANSI B31.1.0 as applicable. The design of Category III pumps and valves shall meet the requirements of good industrial practice. The design of Category II vessels shall meet the requirements of ASME Code, Section VIII, as applicable. The design of Category III vessels shall meet the requirements of appropriate non-nuclear vessel codes as applicable.
FIGURE 1
RESPONSE SPECTRA,
OPERATING BASIS EARTHQUAKE

Rev. 10-1-73
FIGURE 2  RESPONSE SPECTRA,
SAFE SHUTDOWN EARTHQUAKE

Rev. 10-1-73

- 13 -
APPENDIX A

A letter, dated September 5, 1973, from C.J. Knoll, Director Construction Management Division, Richland Operations Office, AEC, to Hanford Operating Contractors is quoted in its entirety in the following:

"AECM 6301 - Seismic Design Provisions

Recent correspondence from Division of Construction, Headquarters, on the above subject, points out the need to clarify our position on seismic design provisions within the AEC General Design Criteria.

As stated in its Preface and in Part 1.A.1.a., AEC Appendix 6301, "General Design Criteria" (dated November 20, 1972), is to be used in the design of modifications and additions to existing buildings and facilities. Part I, Section C, of these criteria, states that except where otherwise designated within the criteria, earthquake loads shall be in accordance with the applicable section of the International Conference of Building Officials "Uniform Building Code" (UBC). In some specific cases, AECM 6301 requirements are more rigid than those in the UBC.

Application of these seismic requirements to the design of an addition or modification to an existing facility that was not constructed in accordance with the same seismic requirements should be evaluated on an individual case basis to determine the need for full compliance.

It is desirable to design each addition or modification for specified seismic requirements when such design will provide a significant improvement for personnel safety, environmental impact, or valuable property protection. In those situations where modifications and/or additions, although properly designed for seismic forces, do not provide significant seismic protection because of dependence upon structural inadequacies of the existing structure, the practicality of compliance for the new work alone is questionable. Similarly, the design of an addition representing a portion or part of a total facility or operation need not be designed for seismic loadings larger than the existing portions are designed for, again assuming no increase in significant hazards to personnel safety, the environment, or valuable property.

Deviations from the seismic requirement in those situations where it is clearly inappropriate because there are no significant increased hazard to life, the environment, or valuable property is considered to be within the RL Manager's authority. If these prerequisites are not met, then the deviation should be submitted to Headquarters for approval through the RL Manager."
APPENDIX B

STANDARD METHOD FOR CONDUCTING AND EVALUATING
SOIL BEARING TESTS

A. GENERAL

1. This method recommends the use of the loading platform called for by the New York City building code because of its simplicity to construct, although equivalent platforms may be used as approved by the Engineer. Evaluation of test results is patterned after the Boston building code which is more applicable than the New York City code to the type of sands and gravels underlying the Hanford Project.

2. It is not the intent that this soil bearing test be the only criteria for determining safe allowable soil bearing pressures. For heavily loaded foundations and all major structures, other subsurface investigations such as test pits, wash borings, core borings, and soil analyses should be included in the foundation study. The importance of making a thorough exploration of the foundation site cannot be overemphasized. It can be dangerous to base a decision upon soil bearing test data alone. A soil bearing test gives information on the soil only to a depth equal to about twice the width of the bearing plate, and takes into account only part of the effect of time. The ultimate bearing capacity indicated by the soil bearing test represents the ultimate bearing capacity of a foundation the same size, depth and location as the test plate. If the soil is not homogeneous to a depth at least the width of the proposed foundation, the load test results are meaningless as far as bearing capacity is concerned. Consequently, other means of exploration must be employed to investigate and evaluate other factors such as loose, soft, or compressible layers underlying the location under consideration, ground water conditions, etc. Test pits or borings should be used to compare strata at different locations. The number, location and depth of pits or borings must be determined for each job. The size of the job and information from test pits or borings should aid in determining the location and number of loading tests.

3. The 24 hr. period with no measurable settlement before application of the next increment of load may be inconvenient at times. Under extreme emergency conditions, and with the consent of the Design Engineer, it may be possible to reduce the 24 hr. undisturbed period.

4. A square bearing block having an area of four square feet (2' x 2') is recommended for the type of soils encountered at Hanford, and is the
APPENDIX B (cont.)

preferred size for major permanent structures. Under certain circumstances, such as for less important structures, and with the consent of the Design Engineer, a square bearing area of 2 square feet (1.414' x 1.414') may be used. If a 2 square foot bearing area is used, the following modifications apply: The settlement at the allowable design soil pressure (3/8" max. * for a 4 sq. ft. area) shall not exceed 5/16 inch* for the 2 sq. ft. area. The settlement at the 100% overload (1" max. * for a 4 sq. ft. area) shall not exceed 3/4 inch* for the 2 sq. ft. area.

B. TEST PROCEDURE

1. Areas to be tested shall be as near the location and depth of the proposed footings as is practicable.

2. The bench mark, wire supports or stationary board used to measure settlement shall be located at or supported at a point beyond the limits of settlement caused by the test. A level or transit should not be placed too close to the test table as it may rise due to the material being pushed up by the test bearing block.

3. The bearing block shall be placed on undisturbed soil representative of the proposed foundation location at the moisture condition as found, or as may be altered by future wetting.

4. Prior to and during loading, test pits and areas shall be protected against moisture changes in the soil. If it is expected that wetting of the soil will occur at some future time, the soil should be pre-wetted to the desired extent to a depth not less than twice the width of the bearing plate.

5. Care shall be taken in placing loads on the platform to cause as little vibration of the load as possible.

6. Measurements of settlement shall be accurate to 1/32 inch and shall be taken hourly for the first 6 hrs. after loading and at 12 hr. intervals thereafter to determine a 24-hour period without settling.

7. Tests shall not be made on frozen ground.

* These settlement figures are nominal values intended for conventional structures where differential settlement is not a critical factor. In structures where differential settlement is critical, the desired settlement limits should be specifically determined by the Design Engineer for each case.
C. PROCEDURE FOR CHECKING AN ALLOWABLE DESIGN SOIL PRESSURE

1. Apply sufficient load uniformly on platform to produce a bearing pressure of 1000 lbs. per sq. ft. on the soil for one hour in order to seat the bearing block.

2. Remove load and take initial zero settlement reading.

3. Apply sufficient loads uniformly on platform, taking into account the weight of platform, to produce successive soil pressures in increments of 50, 100, 150 and 200 per cent of the proposed allowable design pressure. Each increment of load shall remain undisturbed until no measurable settlement occurs in a 24 hr. period.

4. Record data and plot load and settlement diagrams; see "Sample"-Figure 2. Then plot load-settlement curve; see "Sample"-Figure 3.

5. INTERPRETATION OF RESULTS FROM LOAD-SETTLEMENT CURVE - (See Figure 3)

   The proposed allowable design soil pressure shall be deemed satisfactory if:

   a. The settlement at the allowable design soil pressure is not more than 3/8 inch* and

   b. The increment of settlement obtained under the 50 per cent overload does not exceed 60 per cent of the settlement obtained under the proposed allowable design load and

   c. The critical soil pressure, or a maximum settlement of 1 inch*, has not been reached with the 100 per cent overload. The critical soil pressure is the pressure at which the soil fails. In general, there will be slight settlement for the first few hours after each loading due to natural compression of the soil up to the point where the soil begins to fail. Later readings should show no settlement until the next load is applied. If, however, settlement continues without additional loading, the critical soil pressure has been reached.

   * These settlement figures are for a 2' x 2' bearing area; see item 4 under A., GENERAL of this appendix.
D. PROCEDURE FOR DETERMINING AN ALLOWABLE DESIGN SOIL PRESSURE

1. Apply sufficient load uniformly on platform to produce a bearing pressure of 1000 lbs. per sq. ft. on the soil for one hour in order to seat the bearing block.

2. Remove load and take initial zero settlement reading.

3. Apply sufficient load uniformly on platform, taking into account the weight of the platform, to produce successive soil pressures in increments of 3000 lbs. per sq. ft. until the critical soil pressure is reached. Each increment of load shall remain undisturbed until no measurable settlement occurs in a 24 hr. period. If settlement continues without additional loading, the critical soil pressure has been reached.

4. Record data and plot load and settlement diagrams; see "Sample"-Figure 2. Then plot load-settlement curve; see "Sample"-Figure 3.

5. INTERPRETATION OF RESULTS FROM LOAD-SETTLEMENT CURVE:
(See Figure 3)
An allowable design soil pressure can be selected from the load-settlement curve which meets the following requirements:

a. Is 50 per cent or less of the critical soil pressure

b. Shows a total settlement of 3/8 inch* or less

c. The increment of settlement between the selected allowable design soil pressure and one and one-half times this pressure is 60 per cent or less of the settlement due to the selected allowable design soil pressure.

* This settlement figure is for a 2' x 2' bearing area; see item 4 under A., GENERAL of this appendix.

Revised 10-1-73
APPENDIX B

Figure 1

NOTE

1. CENTER LOAD EQUALS
LOAD OF PLATFORM
TIMES B

2. MEASUREMENTS OF
SETTLEMENT SHALL BE
ACCURATE TO 1/32
AND MAY BE TAKEN BY
LEVEL READINGS OR
READ DIRECTLY FROM A
SCALE ATTACHED TO
THE CENTER COLUMN
WITH A WIRE STRETCHED
BETWEEN UNDISTURBED
POINTS AS A REFERENCE;
OR READ FROM A POINTER
FASTENED TO A STATION-
ARY BOARD WHICH
MULTIPLIES THE SETTLE-
MENT BY THE RATIO OF
LEVER ARMS.

3. THE DISTANCE A + B
SHALL BE 8 FT. MIN.

NOTE: THIS DISTANCE DETERMINED BY
NECESSITY OF GETTING SIGHT
ON ELEV. MARK WITH LEVEL

* See item 4 under A., GENERAL of this appendix.

Revised 10-1-73

SDC-2.1
# APPENDIX B

## Figure 2

### LOAD AND SETTLEMENT DIAGRAMS

<table>
<thead>
<tr>
<th>Soil Bearing Test No.</th>
<th>Project No.</th>
<th>Tested by</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of bearing plate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bearing on type of soil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location (coordinates)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weather Conditions:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temp.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Sample Graph](image)

<table>
<thead>
<tr>
<th>Time in days</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil pressure in thousands of lbs per sq ft</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Settlement in 5% of an inch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Revised 10-1-73  

SDC-4.1
SDC-5.1

STANDARD DESIGN CRITERIA

FOR

HEATING, VENTILATING AND AIR CONDITIONING

This Document Consists of 10 Pages.
STANDARD DESIGN CRITERIA FOR
HEATING, VENTILATING AND AIR CONDITIONING

A. SCOPE

1. These criteria shall be used by Project Design Criteria writers and designers as a basis for the heating, ventilating, and air-conditioning systems at Hanford.

   Note
   The subject matter covered by these criteria is so extensive and the specific requirements of different projects vary so widely, it is not possible to be specific in many areas. It will therefore be necessary to supplement the requirements herein with specific requirements in each Project Design Criteria. (ie The indoor design conditions.)

2. Except as modified by the Project Design Criteria, these criteria shall govern.

3. All system design and equipment selection shall be supported by formal calculations for submission with the project drawings.

4. For general design considerations, see Hanford Standard Design Criteria SDC-1.1, General.

B. REFERENCES

The following references are listed for the convenience of the Project Design Criteria writer and the designer. They are mandatory only where specifically called out in the body of this criteria or by law. References are listed by number and title, but without issue date. The issue in effect on date of design effort is applicable.

1. AMERICAN SOCIETY OF HEATING, REFRIGERATING, AND AIR-CONDITIONING ENGINEERS (ASHRAE)
   a. Handbook of Fundamentals
   b. Guide and Data Book - Systems
   c. Guide and Data Book - Applications
   d. Guide and Data Book - Equipment
   e. Filter Efficiency Ratings - ASHRAE 52
2. NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)
   a. National Fire Codes, Vols 1-10; primarily Vol 4, Building Construction and Facilities

3. AIR MOVING AND CONDITIONING ASSOCIATION (AMCA)
   b. Test Code for Air Moving Devices, AMCA-210
   c. Standard Test Code for Sound Rating, AMCA-300

4. INTERNATIONAL ASSOCIATION OF PLUMBING AND MECHANICAL OFFICIALS (IAPMO)
   a. Uniform Plumbing Code

5. AIR-CONDITIONING AND REFRIGERATION INSTITUTE (ARI)
   a. All Standards

6. UNDERWRITERS' LABORATORIES (UL)
   a. Material Lists

7. AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS
   a. Industrial Ventilation Manual

8. SHEET METAL AND AIR CONDITIONING CONTRACTORS NATIONAL ASSOCIATION (SMACNA)
   a. Low Velocity and Duct Construction Standards
   b. High Velocity Duct Construction Standards
   c. Manual for the Balancing and Adjustment of Air Distribution Systems

9. UNITED STATES GOVERNMENT
   a. Federal Register - Title 29 - Labor, Chapter XVII - Occupational Safety and Health Administration (OSHA)
   b. AEC Manual - Appendix 6301
   c. Federal Standard No. 209a - Clean Room and Work Station Requirements
   d. Federal Register - Title 10 - AEC Section 20.106 - Radioactivity in effluents to unrestricted areas (including Appendix B)
10. HANFORD STANDARDS
   a. HPS-151-M     HEPA Filters
   b. SDC-4.1       Design Loads for Structures
   c. SDC-9.1       Noise Control

11. AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)
   a. N101.1        Efficiency Testing of Air Cleaning
                     Systems Containing Devices for Removal
                     of Particles
   b. 29.2          The Design and Operation of Local
                     Exhaust Systems

C. OUTDOOR DESIGN ENVIRONMENT

1. AIR TEMPERATURE
   a. Winter
      (1) Tri-Cities and 300 Area: The outside design temperature shall be 0°F.
      (2) 100 and 200 Area: The outside design temperature shall be -10°F.
   b. Summer
      The outside design temperatures shall be 96°F dry bulb and
      68°F wet bulb.

2. WIND VELOCITY
   For heating and cooling design in conjunction with the above design temperatures, the wind velocity shall be 15 MPH.

3. GROUND TEMPERATURE
   The ground temperature ten feet below grade shall be 55°F.

4. STRUCTURAL LOADS
   For wind and earthquake loads refer to Hanford Standard SDC-4.1, Design Loads for Structures.

5. SOLAR RADIATION
   Values for solar radiation shall be taken from the ASHRAE Handbook of Fundamentals for a latitude of 48 degrees North.
D. **INDOOR DESIGN CONDITIONS**

Economic considerations and facility use shall be weighed for each project and the desired values included in the Project Design Criteria.

E. **DESIGN CALCULATIONS**

1. Heating load calculations shall follow the procedures of Chapter 21 in the ASHRAE Handbook of Fundamentals.

2. Cooling load calculations shall follow the procedures of Chapter 22 in the ASHRAE Handbook of Fundamentals.


F. **OUTSIDE AIR**

1. **COMFORT**
   
a. A minimum of 15 CFM of outside air per person shall be provided where occupant density does not exceed one person per 300 cubic feet.

b. A minimum of 25 CFM of outside air per person shall be provided where occupant density is greater or heavy smoking is expected.

2. **PROCESS**

   The quantity of outside air shall meet the requirements of the Industrial Ventilation Manual and the Project Design Criteria.

G. **CONTAMINATION CONTROL**

When there is a possibility of release of radioactive or toxic material in a space, the following considerations apply:

1. The quality of the discharge of the exhaust system shall conform to the requirements established by 10 CFR 20.106 and OSHA.

2. System design shall follow the requirements of the Industrial Ventilation Manual.

3. The number of hoods, doors, etc., that may be open simultaneously shall be established by the Project Design Criteria.
4. The requirements for any redundant or spare equipment shall be called out in the Project Design Criteria. (Also see Section I)

5. Controls shall be provided on the exhaust system so that the relative pressures between areas do not change appreciably under various operating conditions including the shut-down of the supply system by failure or by the fire alarm system.

6. Pressure differentials shall be established so that air flow is from zones of least contamination to zones of most contamination.

7. Filters shall be placed close to sources of contamination to help keep the balance of the system uncontaminated and to prevent cross-contamination between areas in the event of exhaust system failure.

8. The design shall not combine contaminated air with uncontaminated air thereby causing the high efficiency filter bank to be unnecessarily large.

H. METHOD OF COOLING

There are four general methods of cooling. The selection must be based on comfort or process requirements versus cost and will be called out in the Project Design Criteria. (Prior study may be required.)

1. Mechanical refrigeration can maintain a space at specified conditions (temperature and humidity) within very close tolerances under any specified external conditions and loads. It is also usually the most expensive.

2. Evaporative cooling can provide for removing large sensible heat loads at a reasonable cost, but the resulting temperature is often not low enough and the high humidity may be undesirable. System capacity varies with outdoor wet bulb temperature.

3. Mechanical ventilation can remove large quantities of heat, but at best the indoor temperature will be higher than the outdoor air temperature.

4. Gravity ventilation (large roof and low wall openings) can relieve a high temperature under a roof on a hot sunny day.

I. SYSTEM RELIABILITY

In applications where continuous ventilation is necessary for contamination control or to prevent costly shutdowns, standby exhaust (and supply) system capacity should be provided. More than one source of power is desirable. As a general rule, standby ventilation should be provided for facilities (areas) handling radioactive materials. (Also see Paragraph G.4.)
J. DUCT DESIGN

1. Ductwork shall be designed in accordance with the methods of Chapter 25 in the ASHRAE Handbook of Fundamentals.

2. For material handling of dust collection, refer to the requirements of the Industrial Ventilation Manual.

3. Duct construction shall conform to the SMACNA Manuals.

4. Test connections for static pressure measurements and the insertion of pitot tubes and/or anemometers shall be provided in the design drawings as required for balancing.

5. Pressure reduction and volume dampers shall be provided for balancing the system as designed.

6. In special cases, the Project Design Criteria shall state either the material being transported or the material to be used for the ducts.

K. FIRE PROVISIONS

The design shall conform to the NFPA Fire Code. Special consideration shall be given to the shutdown of the various air-moving systems. Each system shall be evaluated separately with careful attention to all pertinent factors. Evaluate such items as containment of radioactive particles, spread of fire, and removal of smoke and fumes. The system shall prevent the spread of contamination above the limits of 10 CFR 100 for a maximum credible fire as defined in the Project Design Criteria.

Where applicable, equipment shall be UL listed.

L. AIR CLEANING

1. SUPPLY AIR

All supply systems shall be provided with 8% NBS (atmospheric dust) prefilters and a minimum of 35% NBS (atmospheric dust) secondary filters. (Exception to this requirement should be considered for a structure such as a warehouse.)

2. EXHAUST AIR

For cleanliness requirements, refer to Para. G.1.

A useful source of system information is ORNL-NSIC-65; Design, Construction, and Testing of High-Efficiency Air Filtration Systems for Nuclear Application.

WARNING - See Following Page
WARNING

The above manual contains details that do not meet the present level of construction at Hanford. It will be necessary to verify design with local experienced designers. Requirements by necessity must closely follow the state-of-the-art.

3. CLEAN ROOMS

The "Class" of clean room per Fed Std 209a shall be designated in the Project Design Criteria. Clean Rooms are covered in some detail in Chapter 13 of ASHRAE-Application.

4. TESTING

HEPA and critical filter systems shall be designed to be tested per ANSI N101.1. Means for introducing test material and taking samples are required in the design drawings.

M. FRESH AIR INTAKES

At Hanford there is a high concentration of particulate matter at ground level. Therefore, the fresh air intakes should be located at a minimum of 10' above grade and preferably on North or East walls. Where this is not possible, a low velocity "drop-out" area shall be provided inside the structure.

N. INSULATION

In the absence of specific values, the maximum overall heat transfer coefficient for roofs should be 0.15 Btu/hr/sq ft/F and walls 0.20 Btu/hr/sq ft/F. (The engineer must verify this with the architect.) (Lower values are desirable.)

O. EQUIPMENT SELECTION

1. FANS

   a. Fans shall be rated per the AMCA Standard and carry their seal of approval.

   b. Where contaminated air is being handled by the fan, the bearings shall be external to the air-stream and the casings shall be air-tight.
c. Each fan-motor-drive assembly shall be assembled at the factory and balanced at operating speed. Test results shall be furnished with the Certified Vendor Information Data. (Not required for small utility fans.)

d. Fan shall be selected at approximately its point of maximum mechanical efficiency. (This is an area of stable operation and best minimizes changes in operating conditions.)

e. The minimum motor size shall be specified and should be conservatively rated with consideration of non-standard air conditions and high ambient temperatures.

f. V-belt drives shall be selected for 150% of the motor nameplate rating. Multiple belts shall be matched sets.

g. Axial flow fans require close attention to noise considerations.

2. FILTERS

a. General

A permanently installed means for measuring the differential pressure across each filter stage shall be provided. With proper valving and piping, one gage may service several adjacent stages.

b. Filter Banks

Access doors of convenient size shall be provided in the casing and at least a 3' working depth shall be provided in front of the filters for servicing.

c. HEPA Filters

The type of HEPA filter (Type A, B, or C) per HPS-151-M needs to be specified. HEPA filters shall be supplied with pre-filters.

d. Supply Systems (Ref para L.1)

Filters shall be dry replaceable media or automatic roll type for central station supply systems conforming to Class 1 of NFPA 90A, Section 5.

3. COILS

a. General

(1) Casings shall be designed to provide a uniform air velocity across the face of the coil.
(2) Casings and piping shall be designed to allow for expansion and contraction to prevent stresses at the coil connections.

(3) Stacked coils shall be supported individually in a structural framework to facilitate individual coil removal without disturbing adjacent coils.

(4) Steam coils shall be factory tested at a minimum pressure of 150 psig and shall have inner steam distributing tubes.

b. Steam Preheat Coils
Steam preheat coils continuously handling 100 per cent outside air shall have a control system that maintains a continuous flow of steam when the temperature is below freezing. The control system shall also prevent overheating in mild weather. The coils shall not have more than 8 fins per inch and not more than one row deep.

c. Cooling Coils
(1) Provisions shall be made for collecting and removing moisture condensed on cooling coils. Entrained water shall be prevented from being carried down the ductwork.

(2) On direct expansion coils, control shall be provided to prevent the condensed moisture from freezing. Most problems occur at light load.

4. CONTROLS

a. All heating, ventilating and air-conditioning systems require some form of control. In most cases this control will be automatic. Personal comfort normally requires only temperature control.

b. Flow controllers should be considered for applications such as laboratories with exhaust hoods where different modes of operation can affect flow conditions.

c. Differential pressure controllers, dampers, and variable volume/pressure fans should be considered when it is necessary to maintain spaces at different static pressures.

d. Control systems should generally be pneumatic except for small installations where there is no suitable air supply. The control air shall be maintained at a dewpoint of -40 F measured at atmospheric pressure.
5. REFRIGERATION SYSTEMS

The cooling capacity in BTUH of a refrigeration system shall be specified rather than the capacity of the individual components and the responsibility for performance shall rest on one contractor.

P. NOISE


2. The sound produced by the HVAC system shall not exceed the NC-45 Noise Criteria Curve for normal working areas such as offices and laboratories. For auditoriums or lecture areas the sound level shall not exceed the NC-35 Noise Criteria Curve.

3. In areas of high background noise, no special effort shall be made to reduce the HVAC noise level more than 3 dB below that of the background.

4. In areas of low noise level, the possibility of cross-talk between rooms shall be considered and provisions made to prevent same.

Q. BALANCING

The balancing of the air handling system shall be accomplished in such a manner that each space is receiving its designed air supply and proper differential pressure are established between zones. For balancing procedures reference the SMACNA balancing manual.
STANDARD ELECTRICAL DESIGN CRITERIA
FOR
OUTSIDE LIGHTING AND
AERIAL DISTRIBUTION SYSTEMS

This Section consists of 12 pages.
STANDARD ELECTRICAL DESIGN CRITERIA

7.2 OUTSIDE LIGHTING AND AERIAL POWER DISTRIBUTION SYSTEMS

This section of the Design Criteria covers the design of aerial power distribution systems and associated outside street and fence lighting installations, 13.8 kV and under, at Hanford.

A. GENERAL

1. Codes and Standards


   b. Overhead lines shall be designed to meet the requirements for NESC Grade B unless a lower grade is specified in the Supplemental Design Criteria. The assumed conductor loading shall be as specified by NESC for Medium Loading District.

   c. Hanford Electrical Standards, detailing many types of pole structures, are contained in the Electrical Standards Book. They shall be used in the design of aerial systems where applicable, and are briefly listed as follows:

<table>
<thead>
<tr>
<th>Basic Distribution Assemblies</th>
<th>Section - Elect. Std. Book</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin and Insulator Assemblies; Crossarms and Crossarm Assemblies; and Racks</td>
<td>E-1</td>
</tr>
</tbody>
</table>

Clearances

   | Clearances Over Roads, Buildings and Other Lines, etc. | E-2 |

Distribution and Fence Grounding

   | Pole Structures; Substation Fence; and Other Fences | E-3 |

Guying Assemblies

   | Concrete Anchor; Horizontal and Down Guy Assemblies | E-4 |

Rev 5-15-73

SDC-7.2
### 5000 Volt Distribution Structures

<table>
<thead>
<tr>
<th>Section - Elect. Std. Book</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three-Phase Tangent, Turn, Dead End, Tap and Transition to Underground Structures</td>
</tr>
</tbody>
</table>

#### Fence and Street Lighting

- Street Lighting Assemblies; Luminaries; Security Fence Lighting Pole Structures; Combination Lighting and 5000 Volt Distribution Structures.

#### Aerial Cable and Transformers

- Aerial Cable Tangent, Angle and Tap Structures; One and Three Cluster Mounted Transformers on Poles; Transformer Connections.

#### 13.8 kV Distribution Structures

- Tangent, Turn, Dead End, Tap and Transition to Underground Structures

#### Fire Alarm and Communication

- Box Grounding; Aerial Structures; Cable

#### Underground Distribution

- Ducts; Pole Risers; Drains; Marker Post; Direct Burial Details

---

**d.** See also the following sections of Standard Design Criteria:

- SDC-7.4 Underground Power Distribution Systems
- SDC-7.5 Interior Power and Lighting Systems
- SDC-7.7 Communication, Signaling and Control Systems
- SDC-7.8 Fire Alarm Systems
2. Soil and Climatic Conditions

a. Hanford soils vary from fine sand to coarse gravel and rock. Sandy areas are common throughout the area. Loose, dry sand should be assumed in the determination of overturning loads for poles and provision of adequate guyng unless each location is individually investigated.

b. Extremes of air temperature may be from -20 to 110 F, and the frost penetration may reach 36 inches.

3. Drawings

a. A map or site plan(s) shall be prepared to show all outside electrical work including revisions and additions to existing pole line or underground duct systems. The location of each pole, structure, manhole, vault, etc., shall be shown by coordinates or by stationing. All obstructions and possible interference such as underground pipe lines shall be shown. Hanford Electrical Standard drawings and specifications shall be used where applicable by reference to the standard number. Detailed construction drawings of special pole structures, manholes, vaults, etc., shall be prepared. Wire and cable schedules, sag and tension data, and other pertinent information shall be included or referenced on the drawings.

b. Plans for electrical systems shall be coordinated with all other maps and drawings of the area to insure non-interference with other electrical work, other services and equipment, or building structures.

c. Existing and proposed new electrical distribution and communication lines and equipment shall be identified and referenced according to their present or probable future operating designations.

d. Electrical distribution, communication, and fire alarm systems shall be coordinated to assure maximum economy in the joint use of pole lines.

e. The location of building services including electric power, communications, and fire alarm shall be clearly shown on the drawings.
B. GROUNDING

1. Ground conditions are generally such that very little conduction is obtained from ground rods during the dry season. For this reason, special consideration shall be given to all grounding installations.

   a. Where practicable, ground conductors shall be carried to underground water systems or area grounding systems as shown on Hanford Standard E-3-4. If no such connection is available, the methods shown on Standards E-3-1, 2, or 3 may be used. See Instruction, DI-E-3-1 to 4.

   b. Where equipment on poles (switches, etc.) is operated or accessible from the ground, an equipotential mat shall be provided, as shown on Hanford Standard E-3-3, to prevent steep potential gradients in the earth.

2. Substation fences and fences enclosing electrical equipment shall be grounded in accordance with Hanford Standard E-3-10.

3. Metal perimeter and security fences where crossed by aerial power lines shall be grounded to a water pipe or other low resistance ground if a suitable ground is available within 100 feet of the crossing. Where fences are paralleled by a line within a horizontal distance equal or less than the vertical height of the line, or where no suitable ground is available at line crossings, each main gate post shall be grounded to a low resistance ground. Details of the above are covered in Standard E-3-12.

C. DISTRIBUTION VOLTAGES

1. For new construction at Hanford, the distribution and service voltage may be as follows:

   a. 120/240 volt, 3-wire, single-phase, with neutral grounded.

   b. 120/208Y volt, 4-wire, 3-phase, with neutral grounded.

   c. 277/480Y volt, 4-wire, 3-phase, with neutral grounded.

   d. 2400 volt, 3-wire, 3-phase, delta, with neutral grounded through grounding transformer and resistor.
e. 2400/4160Y volt, 4-wire, 3-phase, with neutral grounded.

f. 13,800 volt, 3-wire, 3-phase, delta, with neutral grounded through grounding transformer and resistor.

2. For extension to existing distribution systems the voltage and grounding are fixed. See SDC-7.5 for other systems in use at Hanford.

D. CONDUCTORS

1. Open Wire Conductors

a. Open wire on crossarms shall, in general, be used except where special considerations make it more practical to use some other type of construction.

b. Where possible, the phase sequence (A-B-C) of open wire conductors and cables shall be from top to bottom and left to right when facing the source of power.

c. Conductor clearances shall be according to Hanford Standards E-2-1, 5, and 6.

d. Copper is preferred for overhead line conductors unless otherwise specified in the supplemental design criteria. Medium hard-drawn copper wire is suitable for the majority of requirements, but hard-drawn wire may be used where higher strength is necessary. No. 6 Awg copper is the minimum that may be used for open lines. Other materials which may be considered are as follows:

(1) Copperweld - copper composite conductor may have economic advantages where the span length would be unduly limited by the conductor strength.

(2) Copperweld conductor may be used for street lighting, fire alarm and signal circuits, and lightly loaded distribution lines. Minimum size shall be No. 10 Awg.

(3) ACSR (Aluminum Cable Steel Reinforced) conductor possesses a high strength to weight ratio and is suitable for long span construction.

(4) ACAR and high-strength aluminum conductors may be used where the strength of ACSR is not required.
e. Open-wire line conductor splices shall be of the twisted sleeve or compression type. Self-gripping (automatic) tension splicing sleeves shall not be used.

f. Line conductors shall be secured to pin insulators with soft annealed hand-wrapped wire ties. Each tie should securely bind the conductor to the insulator to resist chafing. The tie shall snugly engage the conductor on each side of the insulator. Composition of ties must be similar to the composition of the conductors. Preformed aluminum armor rods with center marking shall be used for conductor protection at tie points with certain ACSR and stranded aluminum conductors. Applications include (1) single-insulator side-groove tie and double-insulator side-groove tie for use on pin insulators at angles in the line, (2) single-insulator top-groove tie and double-insulator top-groove tie for use on pin insulators tangent in the line, and (3) double-side-groove ties and double-top-groove ties where necessary to provide additional strength and security. The method of tying each conductor should be illustrated or defined on the drawings and shall include specifications covering composition, grade, size, and length of tie wire.

2. Aerial Cable

a. Aerial cable construction is basically more expensive than open wire but its use may be indicated by the lack of adequate clearance for open lines, safety, regulation, or other considerations.

b. Aerial cable shall be located on the pole above communication, signal and fire-alarm lines, but below open-wire power lines and series street light circuits. If two or more aerial cable circuits are installed on a pole, they shall be arranged vertically according to their voltage with the highest voltage uppermost.

c. Cable rated at 5000 volts shall be used for 2400 and 4160 volt service.

d. See IPCEA Standards Publication No. S-19-81 (NEMA WC-3) Section 4.2 and Appendix K for recommended shielding practice for aerial cables. Stress cones must be provided at all shielded cable terminations.
e. Cables and conductors with polyvinyl chloride insulation or jacket material shall not be installed when the temperature is 15°F or lower.

f. See Hanford Standard E-7-1 for phase identification of aerial cable by means of continuous external ribs.

g. Additional details on the use and procurement of aerial cable may be found in IPCEA Publications S-19-81 and S-61-402, and Hanford Standards HPS-315-E and HPS-318-E, and the Instructions to those specifications.

E. SUPPORTS

Wood poles and wood crossarms are standard and shall be used except in special situations which are subject to individual design.

1. Wood Poles

a. Poles shall be Western Red Cedar cut from live stock and shall conform to ANSI Standard O5.1, Specifications and Dimensions for Wood Poles. All poles shall be air seasoned and butt treated in accordance with the American Wood Preservers' Association (AWPA) Standard C7. Each pole shall be branded or marked as described in ANSI O5.1 as follows:

The brand or mark shall be placed squarely on the face of the pole and at 10 feet from the butt of poles 50 feet or less in length and at 14 feet from the butt of poles 55 feet or more in length. The face brand shall designate the supplier's code or trade-mark; plant location and year of treatment; species and preservative code; and class and length of pole.

The pole roof and gain shall be brush coated with pentachlorophenol-petroleum solution conforming to AWPA Standards P8 and P9. The top of each pole shall have a one-way roof cut sloping 30 degrees (120 degrees with pole axis) and the cut surface shall face at right angles to the pole face.

b. The size of poles will be governed by specific use but the following is required:

(1) Poles smaller than Class 4 shall not be used.

(2) Transformer poles, poles at line angles exceeding 30 degrees and dead-end structure poles shall be not smaller than Class 2.
c. The minimum setting depth for poles shall be according to the following:

<table>
<thead>
<tr>
<th>Pole Length Feet</th>
<th>Setting Depth</th>
<th>Pole Length Feet</th>
<th>Setting Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>6'-0&quot;</td>
<td>65</td>
<td>8'-6&quot;</td>
</tr>
<tr>
<td>35</td>
<td>6'-0&quot;</td>
<td>70</td>
<td>9'-0&quot;</td>
</tr>
<tr>
<td>40</td>
<td>6'-0&quot;</td>
<td>75</td>
<td>9'-6&quot;</td>
</tr>
<tr>
<td>45</td>
<td>6'-6&quot;</td>
<td>80</td>
<td>10'-0&quot;</td>
</tr>
<tr>
<td>50</td>
<td>7'-0&quot;</td>
<td>85</td>
<td>10'-6&quot;</td>
</tr>
<tr>
<td>55</td>
<td>7'-6&quot;</td>
<td>90</td>
<td>11'-0&quot;</td>
</tr>
<tr>
<td>60</td>
<td>8'-0&quot;</td>
<td>95</td>
<td>11'-12&quot;</td>
</tr>
</tbody>
</table>

d. Holes for wood poles shall have reasonably straight sides. Holes shall not be grossly oversize, but shall be sufficiently large to permit use of a tamping bar all around the pole.

e. Backfill around poles in sand and gravel areas shall preferably be compacted by flooding the backfill material as it is placed with copious quantities of water. Where the use of water is impractical, the backfill shall be placed in six-inch lifts and thoroughly compacted by hand tamping. Surplus excavated material shall be placed around the pole in a cone approximately one foot in height.

2. Crossarms

a. Crossarms shall conform to Hanford Standard E-1-15. The 9-foot, 2-inch arms are for ordinary use. Other sizes are included for use on double-circuit lines and for other special use as specified in the various Hanford Standards.

b. Crossarms shall face each other on alternate spans on level construction.

c. Line deviations for 20 degrees or less may be on a double arm mounted to bisect the angle. Buck arms are required for angles greater than 20 degrees.

d. One-piece steel angle crossarm braces shall be used where the conductors are No. 0 Awg or larger. See Hanford Standards E-1-16 and 17, and E-1-20 for use of triple arms, heavy hardware, etc., where larger conductors are required.

3. Racks

Secondary racks may be used to carry circuits of less than 500 volts between lines and to carry conductors No. 0 Awg and smaller. Other aspects of secondary rack application shall conform to Hanford Standard E-1-5.
4. **Insulators**

Insulators for supporting power conductors shall be wet process brown porcelain and shall conform to EEI-NEMA standards for the class. Insulators supporting series street light conductors shall be white porcelain. White insulators shall not be used for any other conductors.

F. **GUYS AND ANCHORS**

1. Guys and anchors shall be designed and installed according to Hanford Standard Instructions DI-E-4-1 and DI-E-4-5 to 9 and E-4-1 to 9, inclusive.

2. In order to avoid confusion, guy strand shall be limited to two grades; Siemens-Martin grade for distribution lines, and High Strength grade for communications messenger and 230 kV structures.

G. **SWITCHES AND CUTOUTS**

Disconnecting switches for the purpose of sectionalizing lines shall be group operated. Where mounted on poles, sectionalizing switches must be equipped with a lockable lever for operation from the ground.

H. **LIGHTNING ARRESTERS**

Lightning arresters shall normally be provided in primary-voltage systems for distribution transformer installations of a total capacity of 50 kVA or more (unless there are other arresters installed on the line in the immediate vicinity), for all constant current transformers on both the primary and secondary lines, at transitions between open wire and conduit enclosed systems, and between open wire and aerial cable.

I. **DISTRIBUTION TRANSFORMERS**

1. See Hanford Standard Instruction DI-350-E for standard ratings and tests and Specification HPS-350-E, Outdoor Distribution Transformers, 500 kVA and smaller, 15 kV and under, for procurement specifications.

2. Distribution transformers up to three, 167 kVA are normally cluster mounted on poles. See Hanford Standards E-7-30 and E-7-31, and E-7-35 to 40 for 3-phase connections of single-phase transformers.

3. Pad mounted transformer stations are used primarily for heavy loads, i.e., stations of over three 167 kVA transformers. Pad mounted stations require a steel-mesh type fence with gates for pedestrian and vehicular access except as in the following paragraph. The area inside the fence should be level and covered with crushed rock to a depth of 4 inches. Concrete transformer pads should extend a minimum of 6 inches above the surfacing.
4. Totally-enclosed, throat-connected transformer stations may be installed on a pad without a fenced enclosure. Steel barricade posts shall be specified for protection in traffic areas.

5. For transformer locations near buildings, see "Recommended Good Practice for Transformer and Switchgear Installations," a publication of the Factory Insurance Association. Fire exposure hazards to buildings and personnel from oil-filled transformers, recommended safe distances from buildings, and fire resistive building construction in the vicinity of transformers are covered. The recommendations in that publication concerning transformers located near building entrances and pedestrian walkways shall be adhered to.


J. SERVICES TO BUILDINGS

1. Service conductors to buildings shall not be less than 14 feet above grade at the point of attachment to the structure. Services over roadways, driveways, or service areas shall not be less than 20 feet above grade at any point.

2. Service drop cable may be used where practicable. See Hanford Standard E-7-1 for phase identification of ribbed service cable. Cable for 480 volt services shall be rated 600 volts, but 300 volt cable may be used for 240 volt services.

3. Drip loops shall be a minimum of 6 inches between service cables and the equipment or conduit entrance cap. Service-entrance cables shall not be connected to the service-drop conductors at a point above the level of the entrance cap.

K. OUTSIDE LIGHTING

1. Breakers controlling all outdoor street and fence lighting circuits in an area should be located in a central location within the secured area.

2. In accordance with the AEC Manual Appendix 2401, Part III-B and Exhibit 2, security fence lighting shall produce a minimum illumination as follows:
<table>
<thead>
<tr>
<th>Isolated Fenced Boundaries</th>
<th>Minimum Footcandles at any Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian Entrances -</td>
<td>0.07 with streetlighting or flood-lighting luminaries</td>
</tr>
<tr>
<td>25 feet inside to 25 feet outside</td>
<td>2.0</td>
</tr>
<tr>
<td>Vehicle Entrances - 50 feet inside to 50 feet outside</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Pole Lines for security fence lighting are normally located 10 feet inside the fence line. Details of fence lighting installations are shown on Hanford Standards E-6-1, 2, 3, and 4.

3. Street and walkway lighting shall be provided in areas where there is pedestrian traffic after dark. Lighting levels shall be according to recommendations of the Illuminating Engineering Society for the pedestrian and vehicular traffic density and the following.

4. Scientific research in aeronomy and astronomy is conducted at Hanford utilizing facilities on top of Rattlesnake Mountain. The low stray light environment of the Hanford area, combined with a high percentage of clear nights, make this an ideal location for such research. The site is one of the most desirable for upper atmospheric and astronomical optical research remaining in the United States. In order to preserve this advantageous environment, the following shall be observed for outdoor lighting.

   a. Lighting for buildings, streets, fences, etc., shall be designed as close to the minimum requirements as practicable.

   b. The required exterior illumination source shall be clear mercury vapor. Exceptions to this requirement shall be limited to:

      (1) Incandescent lamps of no more than 150 watts in single installations such as may be used to illuminate an exterior doorway, doorstep, flight of stairs, etc.

      (2) Emergency and warning lights where colored lights traditionally are used.
(3) Portable, temporary lighting systems such as used in fire fighting, rescue work, or other nonroutine situations.

c. All lighting fixtures (with exception of 1, 2, and 3 above) shall be shielded from above in such a manner that the edge of the shield shall be level with or below the center of the light source, so that any direct light emitted above the horizontal is minimized. Light-directing refractors shall be considered to be light sources.

d. Illumination of the exteriors of structures shall be permitted only for reasons of building safety or security and shall be held to a minimum to reduce light reflected from walls to sky. Lighting fixtures in such installations shall be positioned to illuminate from the top of the structure downward, rather than from the ground upward.
STANDARD ELECTRICAL DESIGN CRITERIA

FOR

UNDERGROUND POWER DISTRIBUTION SYSTEMS
STANDARD ELECTRICAL DESIGN CRITERIA

7.4 UNDERGROUND POWER DISTRIBUTION SYSTEMS

This section of the Design Criteria covers the design and installation of underground power distribution systems and underground services, feeders, etc., 240 volts to 13.8 kV, at Hanford.

A. GENERAL

1. Codes, Standards, and Voltages Used

a. The following shall be considered the basic codes for underground power distribution.


(2) The National Electrical Code, ANSI C1.

(3) Hanford Engineering Standards for typical elements of underground construction contained in the Electrical Standards Book under Section E-10.

b. Distribution and utilization voltages presently used at Hanford and those preferred for new construction are shown in section 7.5, of the Design Criteria.

2. Drawings

Drawings for underground distribution systems shall show the location of ducts, manholes, risers, etc., by coordinates or by distance from permanent markers. The elevation of conduits, manhole floors, and manhole covers shall be shown. The slope of each duct section shall be indicated in feet (or inches) per hundred feet of duct length. The total length of each duct run shall be indicated. All special construction details not shown on referenced standards shall be completely detailed. Cable lengths, configuration layouts, connection diagrams, and ground connections shall be included where necessary. Cable terminations and splices shall be shown or referenced to manufacturers' instructions.

3. Soil and Climatic Conditions

a. Soil of the Hanford plant area varies from fine sand to coarse gravel with some large rock. For this reason, trenching machines can seldom be used for duct excavation.
b. The atmospheric temperature may vary from -20°F to 110°F, and the frost penetration may reach 36 inches.

B. UNDERGROUND DUCT SYSTEMS

1. Common Use of Ducts

a. Except under unusual circumstances, power and communication cables shall not be run in common duct and manhole systems, although some of the material in this Criteria applies to underground communication system design.

b. Electric power cables shall not be run in ducts or tunnels with steam, water, or other piping unless the cables are mechanically protected from failure of the piping systems, and unless measures have been taken to assure that the design ambient temperature at the cable locations will not be exceeded.

2. Conduits

a. In general, duct banks shall be rectangular in cross-section having one, two, three, four, six, eight or more separate ducts. Commonly used configurations of one to eight conduits are shown on Hanford Standards E-10-1, 2, and 3. Banks of more than eight conduits shall conform to the above standards as closely as possible.

b. All permanent underground conduits shall be encased in concrete except that rigid galvanized steel conduit with a bonded PVC coating is approved for use underground without concrete encasement. See SDC-7.5, paragraph D-1-b. See the following paragraph "i" for the requirements for concrete, and B-6-a for direct burial cables.

c. Conduit materials for concrete encased ducts shall be rigid galvanized steel, Type I bituminous-impregnated wood fiber, or Type I, high impact, plastic conduit. Aluminum conduit shall not be encased in concrete or directly buried. It may be used only in dry locations above ground.

d. Conduits shall be a maximum of 8 inches in diameter. For ordinary construction, 4-inch diameter conduit shall be used in duct banks for power cables.

e. Ducts and conduits shall be sized according to the following table which has been calculated according to NEC rules (Chapter 9, Table 1).
### MAXIMUM ALLOWABLE DIAMETER OF CABLES IN CONDUIT OR DUCT

<table>
<thead>
<tr>
<th>Nominal Normal Size Inches</th>
<th>Cable Diameter - Inches</th>
<th>Number of cables with same O.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>1.51</td>
<td>0.81</td>
</tr>
<tr>
<td>2 1/2</td>
<td>1.80</td>
<td>0.97</td>
</tr>
<tr>
<td>3</td>
<td>2.23</td>
<td>1.21</td>
</tr>
<tr>
<td>3 1/2</td>
<td>2.58</td>
<td>1.40</td>
</tr>
<tr>
<td>4</td>
<td>2.93</td>
<td>1.58</td>
</tr>
<tr>
<td>5</td>
<td>3.68</td>
<td>1.90</td>
</tr>
<tr>
<td>6</td>
<td>4.42</td>
<td>2.39</td>
</tr>
</tbody>
</table>

1. To find the size conduit required for any number, \( n \), of cables of equal diameter, multiply the cable diameter by \( \sqrt{\frac{n}{4}} \) and use this equivalent diameter in the column for four cables.

2. To find the size conduit required for a group of cables of unequal diameters, find the equivalent diameter by means of the following equation:

\[
d_e = \sqrt{\frac{n_1d_1^2 + n_2d_2^2 + \cdots}{n_1 + n_2 + \cdots}}
\]

Where \( n_1, n_2, \) etc. are the number of cables of diameter \( d_1, d_2, \) etc. The required conduit size is then found by using this equivalent diameter in the table under the column for the actual number of cables. See paragraph B-5-e for diameter of cables.

f. Factory made fittings shall be used. Bell ends shall be installed at all terminations (except vertical risers on poles). Bends shall be designed for the maximum possible radius. Five degree couplings may be used with intermediate straight tangents to form long radius bends. Joints in wood-fiber and asbestos-cement conduit should be made and installed according to the manufacturer's instructions. Tools made especially for the purpose must be used for cutting tapered joints. See paragraph B-5-f for minimum bending radii of cables.
g. A minimum of one spare conduit shall be provided in all multiple duct banks.

h. Drainage of all duct runs must be provided. Ducts shall be sloped a minimum of three inches per 100 feet between adjacent manholes or from a high point in the duct to the manhole openings. Low points in the duct run should be avoided. If such construction is necessary the low point must be adequately drained. See Hanford Standards E-10-10, 11, and 15 for pole riser and drain details.

i. Concrete for encasement of ducts shall develop a compressive strength of 3000 lbs in 28 days. A minimum of three inches of concrete shall be placed on all sides of the duct and two inches between individual conduits for unreinforced duct banks. Duct runs shall be of special reinforced design under the following conditions, except that duct banks containing steel conduit will not normally require additional reinforcement.

1. Where the top of the conduit is less than 30 inches below the finish grade.

2. Where the top of the conduit is less than 42 inches between the bottom of the rail at railroad crossings or bottom of pavement in heavy traffic areas.

Concrete shall be poured on undisturbed or well-compacted earth, and shall be thoroughly rodded or lightly vibrated to fill all voids. See Hanford Architectural-Civil Standard Specifications HPS-512-AC, Placing Reinforced Concrete, and HPS-510-AC, Batching and Delivery of Concrete.

j. Before cables are pulled in ducts, the ducts shall be prepared by pulling a plug closely approximating the diameter of the conduit through the duct to loosen any burrs and to make certain there are no obstructions. This shall be followed with a wire brush and swab to remove any remaining foreign materials.

k. Duct runs shall be marked with marker posts as shown on Hanford Standard E-10-5. Markers shall be placed at each angle or turn, and approximately 150 feet apart on straight runs.

3. Pole Risers

a. Pole risers shall be galvanized conduit above ground. The concrete envelope shall terminate one foot above grade. Risers shall be grounded at the pole. Risers shall terminate not less
than 15 feet above grade. Risers shall be set out a minimum of 3-1/2 inches from the pole by means of wood blocks or metal brackets. See Hanford Standard E-10-15.

b. Lightning arresters shall be specified where cables connect to aerial conductors. The arrester ground shall be solidly connected to the cable shield with as short and direct a lead as possible. If arresters are used at the other cable end, they should be directly connected to the cable shield. The best possible grounds (water mains or area ground grids) should be obtained where arresters are used.

4. Manholes and Cable Vaults
   a. Manholes shall be located at all junctions, sharp corners, terminations, etc., of duct runs and at strategic locations in long runs to facilitate pulling of cable. See method of calculation, paragraphs C-1 and 2.
   b. Manholes shall not be smaller than 5'-0" wide by 8'-6" long on the inside, and have at least 6 feet clear inside height.
   c. Manhole covers shall be round cast iron heavy-traffic type not less than 30 inches in diameter. Covers shall be identified by cast-in lettering 'ELECTRICAL'.
   d. Covers shall be set at sufficient height to permit adequate surface drainage away from the manhole.
   e. Pulling irons shall be provided in the wall opposite each duct bank entering the manhole.
   f. Cable supports shall be specified as required for adequate and neat racking of the cables.
   g. Lighting shall be provided where low-voltage circuits are available on the basis of one watt per square foot floor area. A convenience outlet shall be installed. Vaporproof fixtures and wiring devices shall be used.
   h. Steps are not required in small manholes but should be provided for larger vaults.
   i. Floors shall drain into a small sump with open bottom or to a sewer connection if available.
   j. Each manhole shall be provided with a grounding connection. See paragraph B-7-a.
5. Cables

a. Conductors for all phases, including the neutral and equipment grounding conductor where used, of each circuit shall be installed in the same conduit. Where physical size of the conductors precludes this procedure, the conductors shall be divided in two or more parallel branches and installed so that all conductors of each branch are run in the same conduit. Runs of one single conductor per duct shall not be used, except in very short runs (20 feet or less).

b. Cable for underground distribution shall be single or multiple conductor, and conform to the following Hanford Standard Specifications for 5 and 15 kV cable.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPS-316-E</td>
<td>Butyl Rubber Insulated, Jacketed Cable</td>
</tr>
<tr>
<td>HPS-318-E</td>
<td>Cross-Linked Polyethylene Insulated Cable (also 600 volt)</td>
</tr>
<tr>
<td>HPS-319-E</td>
<td>Ethylene-Propylene Rubber Insulated Cable</td>
</tr>
</tbody>
</table>

See IPCEA, S-19-81, Part 4, Table 4-1, and Appendix K for recommendations concerning insulation shielding of cables. Shielding is required for single-conductor cables without metallic sheath or armor, and for multiple-conductor cables with non-discharge-resisting jacket, where operating at over 2000 volts. Where multiple circuits pass through a common manhole accessible to personnel, the conductors of those circuits energized at over 600 volts to ground shall be shielded cable. Splices, terminations, and stress cones shall be made according to instructions of, and with materials specified by, the manufacturer of the cable. It should be specified that wire and cable with polyvinyl chloride insulation or jacket shall not be pulled into ducts or otherwise handled when the temperature is 15 °F or lower.

c. Cable shall be color coded by means of colored plastic tape applied in bands a minimum of two inches in width at all terminations and splices and in each manhole.

- A Phase - Red
- B Phase - Yellow
- C Phase - Blue
- Neutral - White
- Equipment Ground - Green or Bare
See the paragraphs under B-7 for use of the equipment ground conductors.

d. Lubricants for pulling in cables may be a thick mixture of soap flakes and water, a mixture of soapstone and water, or commercial lubricants as recommended by the cable manufacturer (not petroleum greases).

e. The following table shows the outside diameter of single-conductor cables conforming with Hanford Standard Specifications HPS-316-E, 318-E, and 319-E.

### APPROXIMATE OVER-ALL DIAMETER IN INCHES OF SINGLE CONDUCTOR CABLES -- FOR USE IN CONDUITS AND DUCTS

<table>
<thead>
<tr>
<th>Size-AWG or MCM</th>
<th>Cross-Linked Polyethylene Insulated HPS-318-E</th>
<th>Butyl Rubber Insulated HPS-316-E</th>
<th>Ethylene-Propylene Insulated HPS-319-E</th>
</tr>
</thead>
<tbody>
<tr>
<td>600 V Type RHW or USE</td>
<td>5 kV</td>
<td>15 kV</td>
<td>5 kV</td>
</tr>
<tr>
<td>6</td>
<td>.32</td>
<td>.59</td>
<td>--</td>
</tr>
<tr>
<td>4</td>
<td>.37</td>
<td>.64</td>
<td>.81</td>
</tr>
<tr>
<td>2</td>
<td>.43</td>
<td>.70</td>
<td>.92</td>
</tr>
<tr>
<td>1</td>
<td>.50</td>
<td>.74</td>
<td>.96</td>
</tr>
<tr>
<td>0</td>
<td>.54</td>
<td>.79</td>
<td>1.00</td>
</tr>
<tr>
<td>2/0</td>
<td>.59</td>
<td>.88</td>
<td>1.05</td>
</tr>
<tr>
<td>3/0</td>
<td>.64</td>
<td>.94</td>
<td>1.11</td>
</tr>
<tr>
<td>4/0</td>
<td>.69</td>
<td>.99</td>
<td>1.16</td>
</tr>
<tr>
<td>250</td>
<td>.77</td>
<td>1.04</td>
<td>1.21</td>
</tr>
<tr>
<td>350</td>
<td>.88</td>
<td>1.15</td>
<td>1.32</td>
</tr>
<tr>
<td>500</td>
<td>1.01</td>
<td>1.28</td>
<td>1.46</td>
</tr>
<tr>
<td>750</td>
<td>1.24</td>
<td>1.47</td>
<td>1.65</td>
</tr>
<tr>
<td>1000</td>
<td>1.41</td>
<td>1.61</td>
<td>1.85</td>
</tr>
</tbody>
</table>

Rev 5-15-73 -7- SDC-7.4
f. Cables shall not be bent to a smaller radius than shown in the following table when pulling, handling, or racking.

**MINIMUM BENDING RADII OF CABLES - SINGLE CONDUCTOR**

<table>
<thead>
<tr>
<th>Cable Diameter Inches</th>
<th>Insulation Thickness 64th In.</th>
<th>Minimum Radius - Multiple of Cable Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Non-Shielded</td>
</tr>
<tr>
<td>1.00 &amp; Less</td>
<td>0 - 10</td>
<td>4</td>
</tr>
<tr>
<td>1.01 to 2.00</td>
<td>11 - 20</td>
<td>5</td>
</tr>
</tbody>
</table>

6. Direct Burial Cables

a. In temporary or remote installations where the cost of ducts is not justified, cables energized at less than 5000 volts may be directly buried. In accordance with the NEC, Article 339, 600 volt, Type UF, feeder and branch circuit cable shall be buried a minimum of 18 inches deep, except that this depth may be reduced to 12 inches if a 2-inch concrete pad or other suitable protection is installed over the cable. For directly buried conductors over 600 volts, Article 710 requires a minimum depth of 42 inches, except that this depth may be reduced by 12 inches for each 2 inches of protective concrete above the conductors. Direct burial cables under roads and railroads shall be in concrete encased ducts a minimum of 30 inches deep in accordance with Standard E-10-1, or a minimum of 36 inches deep if installed in heavy-wall steel conduit without encasement. See paragraph B-2-i for reinforcement requirements.

b. Cables shall be embedded in screened sand backfill, and shall be covered with one by eight inch pentachlorophenol-treated boards in the absence of other protective covering. See Standard E-10-20. Underground runs shall be marked with marked posts as shown on Standard E-10-5.

c. Branch circuit and feeder cable runs shall include an equipment grounding conductor sized in accordance with the NEC, Table 250-95.

7. Grounding and Grounding Conductors

a. A grounding conductor shall be included in the concrete duct envelope (not in a duct) and connected to an existing ground, preferably at the power source. Grounding conductors shall be interconnected at manholes. Ground conductors for direct-burial or encasement in concrete shall be steel strand wire, Common Grade, with Class B zinc coating as per ASTM A475, not smaller than 5/8 inch in diameter.
b. Where a transformer or bank of transformers supply a single service disconnecting device or group of devices at the same location through an underground duct or cable, the system neutral shall be grounded at the transformer only. This will require the use of an equipment grounding conductor run inside the service conduit with the power conductors.

c. All metallic conduits shall be grounded, preferably at both ends. Metallic conduits shall not be used for grounding conductors.

d. The metallic shield of high-voltage cables shall, in general, be grounded at both ends of the cable and at each splice. Short lengths of cable (for example, a direct feed from an aerial line) may be grounded at only one point. Where grounding conductors are part of the cable assembly, they shall be connected to the shielding at both ends. Grounding connections to cable shields must be made to provide a permanent low resistance junction. In general, the connection shall be soldered at several points. The braid or strap used to bring out the shield connection must be of ample size to carry fault currents.

C. CABLE PULLING TENSION CALCULATIONS

1. Pulling Tension Equations

a. The pulling tension for a given duct section shall be calculated as follows:

(1) For straight ducts

\[ T = Lw \cdot f \]

where

- \( T \) is the pulling tension in lbs,
- \( L \) is the length of duct in feet,
- \( w \) is the weight of cable in lbs per ft, and
- \( f \) is the coefficient of friction which, for well constructed ducts, may be taken as 0.5

(2) For ducts having a curved section

\[ T = T_2 + T_1 \cdot e^{f \cdot a} \]

where \( T \) and \( f \) are as above, and

- \( T_2 \) is the tension for the straight section at the pulling end,

- \( T_1 \) is the tension for the curved section at the pulling end,
T₁ is the tension for the straight section at the feeding end,
a is the angle of the bend in radians (radian = 57.3 degrees),
e is 2.718 (Naperian log base).

The value of \( e^a \) is given directly in mathematical handbook tables.

The above equations assume no significant change in elevation of the two ends of the cable. If considerable upgrade or vertical pulls are involved, the weight of the cable in the vertical section must be added to the tension calculated from these equations.

b. The following tensions shall not be exceeded in pulling cables.

(1) Pulling with device attached to strands of copper or aluminum conductors

\[ T_m = 0.008 \text{ (cm)} \]

where

\( T_m \) is the maximum tension in lbs, and \( \text{cm} \) is the circular mil area of a single conductor, the total area of the several conductors in a single cable, or the total area of all cables pulled at the same time.

(2) Pulling with basket grip

\[ T_m = 1000 \text{ lb for non-leded cables, but the maximum tension as calculated from equation (1) shall not be exceeded.} \]

(3) Maximum tension at bends

\[ T_m = 100 \text{ } R \]

where

\( R \) is the radius of curvature of the duct in feet. The maximum tension as calculated from (1) and (2) shall not be exceeded.
2. **Example**

Consider the following plan view of a duct layout.

Assume three 500 MCM, 5000 V, rubber insulated, non-metallic jacketed cables pulled together. Weight of single cable is 2.2 lbs per foot.

**Pulling from A to D**

Tension at B

\[ T_B = L \times w \times f \]

\[ = 150 \times 3 \times 2.2 \times 0.5 = 495 \text{ lbs} \]

Tension at C

\[ T_C = T_B \times \theta \]

\[ \theta = \frac{90}{57.3} = 1.57 \text{ radians} \]

\[ \theta = e^{0.5} \times 1.57 = e^{0.785} = 2.19 \]

\[ T_C = 495 \times 2.19 = 1084 \text{ lbs} \]

Tension at D

\[ T_D = T_C + L \times w \]

\[ = 1084 + (30 \times 3 \times 2.2 \times 0.5) \]

\[ = 1084 + 99 = 1183 \text{ lbs} \]

Total pulling tension required.
This value exceeds the allowable 1000 lbs for a basket grip over all three conductors, but the pull could be accomplished with a separate basket grip over each conductor. Or the cables could be pulled with a pulling device attached to the conductor strands because in this case

\[ T_m = 0.008 \text{ (cm)} = 0.008 \times 3 \times 500,000 = 12,000 \text{ lbs} \]

The maximum allowable stress at the bend is

\[ T_m = 100R = 100 \times 4 = 400 \text{ lbs} \]

This is exceeded by the tension required at C \( (T_C = 1084 \text{ lbs}) \) and therefore the cables could not be safely pulled from A to D.

Pulling from D to A

\[ T_C = 99 \text{ lbs} \]
\[ T_B = 99 \times 2.19 = 217 \text{ lbs} \]
\[ T_A = 217 + 495 = 712 \text{ lbs total tension required.} \]

This is satisfactory in all respects. A basket grip or device could be used and the allowable tension at the bend (400 lbs) is not exceeded by the tension at B (217 lbs). A lower tension will always be obtained by placing the let-off reel at the end nearest the bend.

D. CURRENT-CARRYING CAPACITY OF CABLES

The size of cables is dependent upon three factors, (1) the allowable voltage drop, (2) the short circuit current of the system, and (3) the desired operating conductor temperature, which must not exceed the maximum temperature rating of the cable.

1. Voltage Drop

The voltage drop may be calculated, knowing the current, length, and the a-c resistance and reactance of the conductors. Charts published by cable manufacturers are useful for that purpose.

2. Short Circuit Current

The cable shall be sized to carry safely the short-circuit current of the system. For copper conductors the allowable short-circuit current is:
I = 0.0549 cm $\sqrt{\frac{1}{T}}$

where

cm is the area in circular mils and

T is the required time in seconds for operation of the circuit breakers. The equation is based on 80 C temperature rise with no heat transfer from the conductors.

See also IPCEA Publication P-32-382, Short Circuit Characteristics of Insulated Cable.

3. **Current Ratings of Cables**

See IPCEA Publication P-46-426 (IEEE S-135-1) Vol 1, Copper Conductors or Vol 2, Aluminum Conductors, for ampacities of rubber or thermoplastic-insulated cables. The tables are for 1, 8, 15, and 25 kV, with conductor temperatures of 60 to 90 C, for single-conductors in ducts, directly buried and in air, and for triplexed and three-conductor cables.
SDC-7.5

STANDARD ELECTRICAL DESIGN CRITERIA
FOR
INTERIOR POWER AND LIGHTING SYSTEMS
STANDARD ELECTRICAL DESIGN CRITERIA

7.5 INTERIOR POWER AND LIGHTING SYSTEMS

A. SYSTEM VOLTAGE AND SERVICES

1. Systems

   a. Utilization voltages (alternating current, 60 Hz) in use at Hanford are as follows. Preferred nominal system voltages as standardized by ANSI C84.1 (EEI-NEMA Std), are shown.

      (1) 120/240 volt, 3 wire, single-phase, with neutral grounded.

      (2) 120/240 volt, 4 wire, 3-phase, delta, grounded at the 120 volt neutral tap.

      (3) 208Y/120 volt, 4 wire, 3-phase, with neutral grounded.

      (4) 480 volt, 3 wire, 3-phase, delta, ungrounded.*

      (5) 480 volt, 3 wire, 3-phase, delta, with 'B' phase grounded.*

      (6) 480Y/277 volt, 4 wire, 3-phase, with neutral grounded.

      (7) 2400 volt, 3 wire, 3-phase, delta, ungrounded.*

      (8) 2400 volt, 3 wire, 3-phase, delta, with neutral grounded through resistor and grounding transformer.

      (9) 2400/4160Y volt, 4 wire, 3-phase, with neutral grounded.

      (10) 13,800 volt, 3 wire, 3-phase, delta, with neutral grounded through resistor and grounding transformer.

   b. All new 480 volt system design shall be 480Y/277 volt with grounded neutral.

* Only for extensions in existing areas where these systems are installed.
2. **Utilization Requirements**

a. A 120/240 volt, single-phase system is ordinarily used for small buildings with fractional horsepower motors, domestic-size water heaters, or other minor heating loads.

b. Three-phase systems at 240 volts shall be used only when the load is predominantly heating. The use of 240 volts to supply motor loads shall be limited to locations where no other service voltage is available and where the total motor load is ten horsepower or less.

c. Four-wire, 208Y/120 volt, three-phase systems may be used for buildings of moderate size where the load is mainly lighting but may include motor loads of not more than a total of ten horsepower.

d. Three-phase power systems of 480, 480Y/277 or 2400Y/4160 volts or a combination of these services shall be employed for buildings which have a number of integral horsepower motors, very large motors, or other heavy power loads. The lighting system may be supplied at 120 or 277 volts by means of auxiliary transformers or a separate lighting service.

e. Primary systems of 2400, 4160 or 13,800 volts, depending on the distribution voltage in the area under consideration, shall be used for large industrial or process buildings. Unit type substations and metal-clad switchgear should be used with these voltages. For example, a main 13,800-2400 volt unit substation, usually located outside the building, may supply a main bank of 2400 volt metal-clad switchgear with feeders to 2300 volt motors and 2400-480 volt load-center substations. The final utilization voltages and layout of power systems will be dependent upon the load to be served, the reliability of the service desired, and the relative costs of alternate feeder distribution systems. See Power Systems, paragraphs I-1, 2, and 3 of this Section of the Criteria.

3. **Building Services**

a. Service conductors shall be enclosed in rigid galvanized steel conduit or other corrosion resistant ducts from the service connection to the main disconnecting device(s).

b. Services may be overhead or underground depending on cost, occupancy, location, etc.
c. Aerial service conductors shall be a minimum of 14 feet above grade at the point of attachment to the structure. Services over roadways, driveways, or service areas shall be not less than 20 feet above grade at any point. Mast arms attached to low buildings or a pole set adjacent to the structure may be used to meet these requirements. See Hanford Standard E-2-5 for required minimum clearances of conductors over roads, railroads, buildings, etc.

d. Service switches or main circuit breakers shall be located as near as possible to the origin of the service, preferably near an entrance to the building or in an electrical equipment room. The number of service disconnecting devices shall not exceed that permitted by the National Electrical Code (NEC).

e. Service disconnecting switches, where used, shall be heavy-duty, fusible type with interlocking cover, NEMA Type I. When used with grounded distribution systems, the entrance switch shall be equipped with a grounded neutral bar.

B. FEEDERS AND BRANCH CIRCUITS

1. Drawings

a. A riser or one line diagram shall be shown on the electrical drawings to indicate the rating and interconnection between the service, entrance equipment, feeders, distribution panels and branch circuit panels. The conduit and wire size should be noted and the circuit in each conduit identified. A Feeder Schedule shall be included for large buildings.

b. All branch circuiting must be clearly shown on the drawings. The method of switching and the outlets which are controlled by switches must be indicated. The panel designation and circuit number shall be shown for each circuit.

2. Design

a. The voltage drop in feeders and branch circuits shall be limited to that allowed in paragraph 215-3 of the NEC.

b. Design loads for branch circuits shall be calculated in accordance with Article 220 of the NEC.

c. Conductor sizes for inside electrical wiring shall be selected according to (1) Article 310 of the NEC, (2) the allowable voltage drop as in paragraph (a) above, and (3) demand factors not exceeding those permitted by the NEC.
3. **Identification of Equipment**

Main service equipment, feeder panels, branch circuit panels, controllers, and switchgear must be properly identified after installation by means of lettering on or nameplates attached to such equipment. See Hanford Std. E-14-15 for nameplates. This information shall include the designation, use, voltage, and number of phases.

C. **GROUNDING**

1. **System and Service Grounding**

   a. A grounding system must be established for each building or substation to maintain ground potential on conductors and apparatus connected to the grounding system and to dissipate currents conducted or induced into the grounding system. Typical grounding details are shown on Standards E-12-1, 2, 5 and 6.

   b. Where a transformer or bank of transformers supply a single service disconnecting device or group of devices at the same location through an underground duct or metal enclosed busway, the neutral conductor (where used) and the equipment grounding conductor shall be grounded at the transformer only. See Standard E-12-1. If two or more services are fed from the same transformer(s), the neutral shall be grounded at the transformer and at each service disconnecting device or group of devices. The equipment grounding points will then be at the individual service disconnect device(s). Delta-connected, 480 volt, 3-phase systems in some existing Hanford areas have the 'B' phase grounded at the transformers and the 'B' phase conductor must not be grounded at any other point.

   c. The ground connections at the transformer and service disconnecting device must be readily accessible.

   d. Service ground conductors shall be sized according to the NEC, Table 250-94(a), but shall not be smaller than No. 6 Awg stranded bare, or with green color insulation. See Hanford Standard E-12-10.

   e. Where subject to mechanical injury, the grounding conductor shall be protected in accordance with NEC, paragraph 250-92(a), except that a nonmagnetic material shall be used for the protective enclosure.

   f. The service ground shall be connected to the building ground grid or mat where grids are available.
g. For smaller buildings, the ground connection may be made to the nearest cold water piping ahead of meters, valves, etc. An approved-type, galvanized steel, pressure clamp shall be specified for attaching the grounding conductor to galvanized water pipes. Copper-alloy clamps shall be used with copper or brass pipe. Soldered connections shall not be used. Thermite welded or brazed ground connections are recommended. See paragraph G-6-f for requirements. The ground connection should be visible if possible.

h. See SDC-7.4 for grounding of underground high-voltage cable systems.

2. Grounding Electrodes

a. Where attachment to water piping will not provide adequate grounding capacity, ground buses or grids shall be installed. A ground bus of two, 5/8 inch cables in parallel, bonded at intervals of not more than 50 feet, shall be buried at least 18 inches below grade around the periphery of the building or installation. The bus shall be connected to ground rods at intervals not exceeding 50 feet and at each corner, and shall be connected to all water lines serving the building at two points on each line. For large buildings or installations, cross ties of single cables shall be used to form a grid. The grid spacing shall be 30 to 50 feet and should match the column spacing or multiples of column spacing, to provide a convenient ground point for the columns. Details of building grounding grids are shown on Standard E-12-5. Ground connection points (plates) for installation in concrete building walls and floors are shown on Standard E-12-6. The upper parts of buildings not otherwise directly grounded shall be bonded to the grounding system with grounding cables.

b. All underground steel grounding cables shall be steel strand wire, Common Grade, with Class B zinc coating in accordance with ASTM Specification A475. See paragraph (e) below for use of copper conductors underground.

c. Ground rods shall be of galvanized steel not less than 5/8 inch in diameter by eight feet in length. They should be driven at least six feet apart in areas where a number of rods are needed to reduce ground resistance. Resistance to ground shall be measured by the voltmeter or Wheatstone bridge methods or by commercial instruments designed for measuring ground resistance. If the measured resistance to ground of a ground rod or rods exceeds 25 ohms, additional rods to a maximum of six shall be installed. Grounding systems for large buildings or substations will require special design depending on location, etc. See reference, paragraph C-4-k.
d. Exposed grounding conductors inside of buildings shall be copper cable, or other corrosion-resistant metal as permitted by the NEC. All connections between copper and galvanized steel shall be exposed and above ground. See paragraph G-6-f. Copper cable used above ground shall not be smaller than No. 6 Awg.

e. For new construction in existing areas having underground copper grounding systems or extensions to buildings with copper grids, it may be preferable to use copper in the new design. The objective is to avoid close proximity of dissimilar metals underground or in wet locations. See SDC-7.10.

f. The installation of a ground mat near stainless steel lines should be avoided. Where establishment of a ground grid near stainless steel piping is necessary, cathodic protection of the stainless steel must be provided. See SDC-7.10 for cathodic protection requirements.

g. Buried grounding cable shall be protected against all mechanical injury before and during backfill. Backfill material within one foot of the cable shall not contain rock larger than two inches in diameter.

3. Equipment Grounding

a. The term equipment shall be understood to mean all exposed metal parts of a wiring system including conduit, raceways, metal armor of cables, cabinets, switch boxes, outlet boxes, motor frames, motor controllers, panels, and lighting fixtures.

b. The equipment ground system shall originate at the transformer(s) or the service grounding point. See paragraph C-1-b. The grounding conductor shall in no case be the system neutral or any current-carrying conductor.

c. Metallic raceways may be used for the equipment grounding conductor only in systems of less than 150 volts to ground for circuits (1) rated at less than 60 amperes, and (2) serving motors smaller than 5 horsepower, but all raceways shall be grounded.

d. A separate equipment grounding conductor shall be used to ground (1) all equipment operating at over 150 volts to ground, (2) all circuits protected at 60 amperes or more, and (3) all motors 5 hp and larger. See Hanford Standards E-12-10, 11, 12, 13 and 14 for approved grounding methods. The equipment grounding conductor must be run inside the conduit or wiring channel enclosing the power conductors supplying the equipment, or in the case of multiconductor cable, must be located inside the sheath of the cable. Where physical limitations prohibit the use of a larger conduit to include the equipment ground conductor, the ground conductor shall be placed as close to the conduit as possible, preferably strapped to it.
e. All metallic conduits, wiring channels, and the armor of armored cable shall be connected at each end to the grounding conductor or firmly attached to each end, with a good electrical contact, to a properly grounded connection box. Ground connections must be made to the grounding conductors at each box.

f. Equipment grounding conductors, including all bonds and jumpers associated with the feeder or branch circuit, shall be sized according to the NEC, Table 250-95. Separate equipment grounding conductors shall have a green color insulation in sizes No. 2 Awg and smaller, but may be bare in sizes No. 1 and larger. Grounding conductors in cables may be bare. All grounding conductors, bonds, and jumpers shall be IPCEA, Class B, stranded wire or cable, except that solid grounding wires where an integral part of NMC, UF, and similar cables, and the metal sheath of MI, MC, ALS, and similar cables, may be used for equipment grounding if in accordance with NEC Table 250-95.

g. Some types of multiconductor power cables are made with two or three grounding conductors placed in the interstices between the larger current-carrying power and neutral conductors. These conductors may be used as the equipment grounding conductor, provided their combined size meets the requirements of NEC Table 250-95.

h. Interlocked armored cable shall be constructed with an internal, separate equipment grounding conductor or conductors. The sheath shall be grounded but it shall not be used as the grounding conductor.

i. In multiconductor cables and cords, the green conductor is to be used as the grounding conductor, and shall not be used for any other purpose except as in the following references. See Hanford Standard E-14-5 for color coding of control cable and E-14-8 for color codes for portable cords.

j. Grounding conductors shall be copper or other corrosion-resistant material as permitted by the NEC. Copper wire and cable shall be annealed. In no case shall hard drawn copper wire or cable be used for grounding conductors, bonds, or jumpers.

k. Receptacles that do not have the grounding contact connected to the mounting strap, where used in systems in which the conduit serves as the grounding conductor, shall have a green color bonding jumper connected from the receptacle ground terminal to the box and conduit. A bonding jumper is required by the NEC, paragraph 250-74, for receptacles unless the exceptions to that rule apply. Exception No. 1 to NEC 250-74 shall not apply to the requirement for a jumper as stated in the following paragraph.
1. Grounding-type receptacles where mounted on flat or raised box covers or in metal partitions by means of the plate fastening screw(s) (strap ears are not fastened to a box) shall have a green bonding jumper connected between the receptacle ground terminal and a grounded box, conduit, or the grounded metal partition framing.

m. Portable electrical equipment must be grounded by means of a separate grounding conductor (green color) in the cord or cable equal in current-carrying capacity to the largest line conductor. The ground must be completed through a separate grounding pole in the plug and receptacle. Equipment grounding is not required for electric clocks or soldering irons.

n. The ground connection to motors and other equipment shall be attached by means of a solderless terminal (solder lugs shall not be used) fastened to the motor beneath the head of a bolt tapped into the frame as shown on Standard E-12-13. Ground attachment to foot bolts or end bell bolts is prohibited.

o. Plug-in or trolley busways shall have an internal grounding bus, and the plug or trolley devices shall have contact stabs or trolleys for making contact with this grounding bus. The grounding bus shall be connected to the grounding conductor at the point of supply and shall make positive electrical contact with the bus enclosure at both ends of the bus run and at intervals of 20 feet or less.

p. In those types of busways where an internal ground bus is not available, the side rails of the bus enclosure shall have a galvanized or corrosion resistant finish. Both side rails shall be positively connected to the grounding conductor at the point of supply, and care should be taken that good electrical connection is made at all splice points along the length of these rails. Connection between rails and the enclosing case of each plug in device shall be made through attachment clamps.

q. Traveling cranes and hoists shall have a separate contact conductor and collector for equipment grounding in addition to those required for the motor and control circuits, unless a positive grounding connection is provided by other means.

r. Auxiliary (external) bonding of the enclosures or frames of electrical equipment to adjacent metal members (building steel, machine frames, pipe, etc.) shall be considered where personnel hazards may exist. The requirements are covered in Standards E-12-1 and 2. The bonding conductor shall be sized according to the NEC Table 250-95, but shall not be smaller than No. 6 Awg, stranded copper or other corrosion-resistant metal, green insulation or bare.
s. A continuous row of lighting fixtures supplied at less than 150 volts to ground may be considered as one fixture if the mechanical connections between fixtures are such that electrical continuity is assured. Fixtures supplied at over 150 volts to ground shall have a grounding conductor connected to each unit.

4. Static Grounding

a. The column footings of all steel frame buildings and all other metal structures shall be thoroughly grounded to a water line or ground mat. Only galvanized steel cables and ground rods shall be used in direct contact with the earth. See exception, paragraph C-2-e.

b. A static grounding system must be provided for steel frame buildings, tanks, etc., and process buildings where hazardous conditions may exist. The main grounding conductors shall be two, 5/8 inch galvanized steel cables laid parallel and bonded together at intervals of not more than 50 feet. The cables shall be buried at least 18 inches deep around the periphery of the building or installations. Metal buildings containing hazards of Class I, Groups A, B, C, and D as defined in Chapter 5 of the NEC, shall have siding and roofing grounded at every fourth panel or sheet, and other building steel such as floor gratings, door frames, railroad track in and adjacent to the building shall be connected to the grounding system.

c. All nonelectrical machinery and equipment located in buildings where flammable gases, solvents, gasoline, metal dust, coal dust, or other flammable material is processed, stored, or otherwise handled must be grounded. This may be accomplished by bonding between several pieces of equipment and making a common connection to a grounded building column or directly to a water main. The main grounding conductor shall be No. 4/0 Awg copper or equivalent. No. 2/0 may be used for branches to large equipment and No. 4 to smaller items.

d. Pipe lines and ducts carrying flammable liquids or vapor must be grounded at points not exceeding 100 feet along the route of the pipe. Where couplings and fittings are not electrically conductive, a bond wire or braid shall be used to jumper such fittings.

e. Flexible grounding cable with a suitable positive clamp attachment must be provided to ground all movable equipment such as railway cars, trucks, etc., which are used in hazardous locations.

f. All gas cylinder manifolds shall be grounded. Manifolded flammable gas cylinder installations shall be provided with a positively grounded aluminum floor plate. See Hanford Arch-Civil Standard AC-1-40a and b.
g. See the National Fire Protection Association's publication No. 77, Static Electricity, for a discussion of the detection and prevention of static charges and suggested methods of grounding.

h. Air terminals (lightning rods) shall be installed on all buildings which contain explosive or easily ignited materials, except as follows:

(1) Where the structure is entirely within the cone of lightning protection afforded by a higher structure such as stacks with terminals or grounded elevated tanks. The zone of protection is usually taken as a cone whose radius is equal to the height of the apex (or a cone generated by the revolution of a right 45 degree triangle).

(2) Tanks or other structures having grounded metal roofs where the roof material is at least 3/16 inch in thickness.

(3) Where the risk from fire instigated by lightning, considering the value of the building and its contents, does not justify the cost of lightning protection.

i. Steel-frame buildings may have air terminals connected to the building steel if such steel is properly grounded and continuous without high resistance joints or if such joints are bonded. For all other construction, the terminals must be connected to a suitable ground by means of a separate grounding conductor. Grounding conductors shall be installed on the outside of the building and coursed in the most direct route to ground without sharp bends or loops.

j. For further details concerning lightning protection and installation recommendations, see ANSI C-5.1 (NFPA 78).

k. For further information and details concerning system grounding, equipment grounding, static and lightning protection grounding, and connections to earth, see the Institute of Electrical and Electronics Engineers (IEEE) Standard No. 142, Grounding of Industrial Power Systems.

D. WIRING METHODS

1. Rigid, Heavy-Wall Conduit

a. Rigid, zinc-coated steel or aluminum conduit shall be used and installed in accordance with Article 346 of the NEC, subject to the following requirements and restrictions.

(1) Rigid, metallic conduit shall be used for all service entrances, and in all hazardous locations.
(2) Threadless fittings shall not be used on rigid metal conduit.

(3) Aluminum conduit shall not be used in poured concrete structures, where encased in concrete, or directly buried in the earth.

(4) Underground runs of steel conduit shall be encased in concrete except as in the following paragraph b.

b. Rigid zinc-coated steel conduit with a bonded polyvinyl chloride outer coating may be used underground without concrete encasement, or in other locations where severe corrosive conditions are present.

(1) The conduit, prior to coating, shall be rigid, galvanized conduit conforming to ANSI C80.1. The PVC coating shall be fused to the surface and shall have a minimum thickness of 40 mils. Coated couplings shall be furnished with each length. Couplings shall have a sleeve extension of one pipe diameter, or two inches, whichever is less. The inside diameter of the sleeve shall be the same as the outside diameter of the conduit. Sleeve thickness shall be not less than the thickness of the conduit coating. The coating of conduit, elbows, and couplings shall have no sags, blisters, lumps, or other surface defects, and shall be holiday-free. It shall be continuous over the entire length of the conduit, and shall be chamfered at the last thread.

(2) Concrete encasement of PVC coated steel conduit may be required under roadways and railways.

c. Rigid, nonmetallic conduit shall be used and installed in accordance with the NEC, Article 347, except where metallic conduit is required by the foregoing paragraph, and subject to the following requirements. Rigid polyvinyl chloride and high density polyethylene conduit are approved by the NEC for underground use, and PVC for use above ground.

(1) Conduit without concrete encasement is approved by the NEC only if the circuit potential does not exceed 600 volts.

(2) An equipment grounding conductor shall be included in all nonmetallic conduit having circuit conductors energized at over 50 volts to ground.
d. Conduit risers through concrete slabs or floors shall be rigid steel. Transitions from plastic conduit runs shall be made under or in the slab or floor. All parts of uncoated steel conduit shall be encased in concrete.

e. Only rigid conduit (except aluminum) shall be embedded in masonry or concrete buildings where moisture may be present. See paragraph D-2-a.

f. Long conduit runs or runs between areas where an air pressure differential exists shall be sealed at both ends to prevent the flow of air through the conduit and consequent condensation of moisture on the inside surface of the conduit. Commercial duct sealing compounds shall be used for this purpose. This does not apply to runs such as pole risers which may be intentionally ventilated.

g. See SDC 7.4 for use of underground conduit and ducts.

2. **Electrical Metallic Tubing (EMT)**
   
a. Electric metallic tubing may be specified for the following (except services) provided that it is installed in a dry location and not subject to impact, abrasion or other mechanical injury:

   (1) Concealed or exposed wiring in attic, floor-joint spaces, walls and ceilings of wood or steel frame buildings.

   (2) Concealed or exposed wiring in masonry or concrete buildings provided the location is permanently dry. See the NEC, Article 348.

   (3) All wiring in wood frame buildings.

b. Electrical metallic tubing shall not be used for runs from building walls or ceilings to machinery.

c. Indentor type fittings for electrical metallic tubing shall not be used.

3. **Flexible Metal Conduit**
   
a. Flexible conduit is permitted in short sections only to make connections to motors or other equipment where the use of rigid conduit is difficult or impractical.

b. Liquid-tight, flexible metal conduit and fittings shall be used as above where the wiring is subject to moisture, oil, vapor, acid, etc. The conduit shall have a built-in grounding conductor. Fittings shall be corrosion resistant.
4. Nonmetallic Sheathed Cable

a. National Electrical Code Type NMC cable may be used for 120/240 volt branch circuits in wood frame buildings. It may be run concealed or exposed provided that no exposure is less than four feet above the floor.

b. A bare, solid grounding conductor, if included in the cable, is permitted provided it complies with the size requirements of the NEC. If no suitable green or bare conductor is furnished, the red wire may be used for the ground conductor provided it is marked with green tape at all junction and outlet boxes.

5. Plug-In Busways

Plug-in busways, trolley ways, etc., should be considered for shops, laboratories and similar areas where the equipment is subject to frequent changes, rearrangement, or expansion.

6. Metal Ducts, Wireways, and Busways

a. Where numerous or large conductors must be accommodated, metal ducts or wireways may be used, although the use of prefabricated trays is preferable where such an installation is practical. See paragraph 7. Wireways are manufactured in standard sizes with boxes, fittings, transitions, etc., or the duct may be fabricated for the particular application.

b. Wireways and busways shall be constructed and installed according to Articles 362 and 364 of the NEC.

c. Wireways shall have hinged covers where accessible to unauthorized personnel, where carrying conductors operating at more than 150 volts to ground, and where the wireway is installed seven feet or less above the floor or passageway.

d. Separate wireways or wireway separators fabricated for the purpose shall be used to separate (1) low-voltage signaling, communication, instrument, etc., conductors (2) power conductors operating at less than 600 volts, and (3) high voltage conductors of over 600 volts.

e. The sum of the cross-sectional areas of all contained conductors at any point in a wireway shall not exceed 20 percent of the interior cross sectional area of the wireway. See also NEC, paragraph 362-5.
7. **Continuous Rigid Cable Supports**

Ladders, troughs, channels, and similar supports for cables shall be constructed, designed, and installed in accordance with Article 318 of the NEC, and the requirements of paragraph 318-6 shall be adhered to for cable ampacities.

8. **Nonmetallic Ducts (Fiber, Cement-Asbestos, and Plastic Conduit)**

Type I fiber or plastic conduit may be used for underground ducts where encased in reinforced concrete. Type II may be used exposed where not subject to mechanical damage.

9. **Interlocked Armor Cable**

Armor cable may be used in all sizes and voltage ratings (600 to 15,000 volts) for feeders and branch circuits provided that the cable is located where not subject to mechanical damage or to corrosive fumes or vapor.

10. **Mineral Insulate Metal Sheathed Cable (Type MI)**

MI cable should be considered where special conditions warrant its use.

11. **Underfloor Raceways**

Metal or fiber underfloor wiring systems may be used in large buildings where it is economically justifiable. See the NEC, Articles 354, 356, 357, and 358.

**E. BOXES AND WIRING DEVICES**

1. **Outlet, Switch, and Junction Boxes**

a. Boxes shall be sized and installed in accordance with Article 370 of the NEC.

b. Boxes used with rigid conduit or EMT in dry locations may be aluminum, galvanized steel, cast iron, or cast aluminum. Boxes used with nonmetallic sheathed cable may be aluminum or galvanized steel of a type especially designed for the purpose. Aluminum boxes shall not be embedded in concrete.

c. Boxes used in wet locations shall be cast iron with a corrosion resistant finish.

d. Outlet boxes, panels, or other electrical equipment must be located at least 10 feet from safety showers. This does not apply to lighting fixtures or electrical equipment located eight feet or more above the floor.
2. **Plugs and Receptacles**

   a. Receptacles and plugs for 480 volt, three-phase service at Hanford are covered by Hanford Standards E-14-40, 45 and 50. NEMA standard receptacles, connectors and plugs as shown in NEMA WD1 shall be used for other service (up to 600 volts) as applicable. Receptacles and plugs shall be Specification Grade. Isolated or regulated 120 volt supply for instrumentation power shall have the receptacle and plug equipment as shown on Hanford Standard E-14-35.

   b. The selection of receptacles for unusual services such as direct-current, odd frequencies or voltages, or heavy current requirements shall be at the discretion of the designer, but the receptacle types reserved by NEMA or as Hanford Standards shall be used for any other purpose.

   c. Receptacles selected for weatherproof or explosion proof service, and receptacles in plug duct, baseboard strips, or underfloor duct outlets shall maintain contact configurations identical to the standard receptacle for the particular service.

   d. Convenience outlets shall be located 18 inches above the floor except in shops or similar areas where the mounting height shall be four feet above the floor. Mounting heights for switches and receptacles in prefabricated metal partitions shall be according to the manufacturer's standard. Mounting height of other receptacles is at the option of the designer and shall be shown on the drawings.

   e. Metal cover plates for outlet boxes shall be used in industrial buildings. Nonmetallic plates may be used in offices.

3. **Switches**

   a. Local lighting switches for all general uses shall be 20 or 30 ampere, 277 volt, totally-enclosed tumbler switches, specification grade. These switches are rated for full current for tungsten filament or fluorescent lamps, and 80 percent current rating for motor loads.

   b. Switches shall be mounted four feet above the floor except for prefabricated metal partitions as in paragraph 2-d above.

   c. Switch plates for industrial buildings shall be metal, but may be nonmetallic in offices.
F. PANELBOARDS

1. General
   a. A Panel Schedule shall be shown on the drawings for each distribution and branch circuit panel. The schedule should include the location and designation of each panel with the type, voltage, and current rating of each branch circuit overcurrent device and the branch circuit number.
   b. Cable and bus conductors in switchgear and panels, and interconnections to such equipment, shall be installed as follows when observed from the front.

<table>
<thead>
<tr>
<th>A Phase</th>
<th>Front</th>
<th>Left</th>
<th>Top</th>
<th>Upper Front</th>
<th>Upper Front</th>
</tr>
</thead>
<tbody>
<tr>
<td>B Phase</td>
<td>Center</td>
<td>Center</td>
<td>Center</td>
<td>Upper Rear</td>
<td>Lower Front</td>
</tr>
<tr>
<td>C Phase</td>
<td>Rear</td>
<td>Right</td>
<td>Bottom</td>
<td>Lower Front</td>
<td>Lower Rear</td>
</tr>
</tbody>
</table>

c. When additions are made to present facilities, panelboards and switchgear shall match and line up with the existing equipment as closely as possible.

2. Types
   a. Circuit-breaker panelboards shall conform to Federal Specification W-P-115A, Type I, Class I.
   b. Panelboards for 120/240 volt systems with mains up to 600 amperes may be the plug-in or bolt-in type. Plug-in breakers are limited to 5000 amperes interrupting capacity.
   c. Panelboards for 480/277 volt system with mains up to 600 amperes shall be the bolt-in type with 15 to 100 amperes breakers rated 14,000 symmetrical amperes interrupting capacity, and 70 to 225 amperes breakers rated up to 35,000 symmetrical amperes interrupting capacity at 480 volts.
   d. Panelboards for heavy power distribution with mains up to 1200 amperes may be used with breakers up to 1200 amperes with interrupting capacity of 85,000 amperes symmetrical at 480 volts.

G. WIRE AND CABLE

1. Building Wire - 600 Volt
   a. Building wire shall be in accordance with Hanford Standard E-14-1. Types THW, THWN, RHH, RHW and XHHW are approved in all sizes for all uses. However, Types RHH, RHW or XHHW are preferred in sizes No. 1/0 and larger for important laboratory and process wiring.
   b. Type TW may be used for nonprocess building wiring, and for equipment grounding conductors in any system.
c. Other types of building wire for specific or unusual applications such as high ambient temperature, extra flexibility, special insulation, high current-carrying capacity, etc., may be substituted for the above.

d. The minimum wire size for lighting and power circuits shall be No. 12 Awg. Smaller conductor sizes may be used in certain control cable or low-voltage applications. Wire sizes No. 8 and larger shall be stranded and No. 10 and smaller may be solid, except that conductors in control cable and grounding conductors shall be stranded. Conductors No. 10 and smaller shall be copper, and No. 8 and larger may be copper or aluminum, as specified. Bare grounding conductors shall be stranded, annealed copper (except those in multiconductor cables having aluminum circuit conductors).

e. The minimum wire size for interior fire alarm systems shall be No. 14 Awg, 7 strand, except for limited energy systems. See SDC-7.8.

f. Wire for use where vibration may be present, in critical circuits, such as metering, relaying, and instrumentation, or where the wire is flexed frequently, shall be stranded (7 or more strands).

2. Multiple Conductor Control Cable - 600 Volt

Multiple conductor cable shall be No. 16 Awg minimum size, 7 or 19 stranded conductor, 600 volt, with PVC, thermoplastic polyethylene, or cross-linked polyethylene insulation conforming to Hanford Standard Specification HPS-314-E, Plastic Insulated Control Cable. Requirements for installation and color coding are covered in Hanford Standard E-14-5.

3. High Voltage Cable

a. Single-conductor cable (5 and 15 kV) shall be butyl rubber insulation in accordance with Hanford Standard Specification HPS-316-E, cross-linked polyethylene in accordance with HPS-318-E, or ethylene-propylene rubber in accordance with HPS-319-E.

b. See SDC-7.2 for use of aerial cable, and SDC-7.4 for underground cable systems in ducts, pole risers, current-carrying capacity, etc. See IPCEA Standard 5-19-81, Part 4 and Appendix K, for recommended shielding practice for high-voltage cables.
4. **Power Circuit Color Coding**

   a. Power circuit conductor color shall be:

      | Phase      | Color            |
      |------------|------------------|
      | A Phase    | Red              |
      | B Phase    | Yellow or Orange |
      | C Phase    | Blue or Black    |
      | Neutral    | White            |
      | Ground     | Green or bare    |

   Pressure-sensitive, colored plastic tape shall be used to identify the conductors in lieu of colored insulation. See also Hanford Standards E-14-1, E-14-5, and E-14-8 for color codes.

   b. The above coding shall be maintained throughout the power systems including service, feeders, and all branch circuits to the connection box at the utilization equipment.

5. **Underground Installations - Direct Burial**

   a. Direct-burial cable may be used in lieu of concrete-encased conduit or duct for circuits of 5000 volts or less where the run is not subject to mechanical injury and the load is non-critical. Multiple-conductor, direct-burial cable shall contain an equipment grounding conductor where required in accordance with NEC, Table 250-95.

   b. Underground runs of direct burial cable for circuits not over 600 volts shall be a minimum of 18 inches deep, embedded in a sand cushion, and covered with one by eight inch creosote-treated boards before backfilling. See Standard E-10-20. Underground runs shall be permanently marked with marker posts in accordance with Standard E-10-5. See SDC-7.4 for 5 kV direct-burial requirements and other details.

6. **Splices, Taps, and Cable Terminations**

   a. Splices and taps in building wire No. 8 Awg and smaller shall be made mechanically strong, soldered and taped except that approved solderless connectors may be substituted in accordance with the following paragraph.

   b. Pressure-type, solderless connectors and terminal lugs may be used. Connectors with insulating caps or covers shall be UL approved for the voltage of the system. Connectors shall be installed according to the manufacturer's instructions using the proper tool for the connector terminal.

   c. Plastic insulating tape made specially for electrical work may be used for all splices and taps in circuits up to 600 volts. The thickness of insulating tape shall be at least equal to that of conductor insulation. Where a bolted splice or connection presents an irregular surface, an insulating putty shall be applied to the joints before taping. Moulded insulating covers for connectors may be used in place of taping.
d. Manufacturer's instructions and directions must be strictly adhered to for splices, stress cones, and terminations in high voltage cable.

e. Cable leads to oil-immersed equipment must be treated to prevent capillary seepage of the oil into the cable insulation.

f. Splices and taps in bare grounding conductors and connections to ground rods, where buried in the earth or concrete, may be made as follows. Brazing or thermite welding (Cadweld or Burndy, Thermoweld or equal) is preferred.

(1) For copper to copper joints, two pressure-type copper alloy clamps, a thermite welded connection, or a brazed joint may be specified. A copper or silicon-copper rod is to be used with torch brazing and phosphor-bronze rod with arc welding.

(2) Galvanized steel cables may be connected by two galvanized pressure clamps, or a thermite weld connection. Welded connections shall be coated with asphaltic paint for a distance of six inches in each direction, one layer of half-lapped cotton tape shall be applied over the painted area, and the tape shall be completely saturated with asphaltic paint.

(3) For copper to galvanized steel joints, the connection must be made above ground using two pressure type clamps or the thermite weld process.

7. Installation of Cables

   a. It should be specified that wires and cables with polyvinyl chloride insulation or jacket shall not be installed or handled when the temperature of the wire or building is 15 F or below.

   b. Powdered talc, or a commercial product made for the purpose, may be used where a lubricant is required for pulling in wire and cable.

8. LIGHTING SYSTEMS

   1. General

       a. Lighting system design shall be based upon maintained intensity levels. The coefficient of utilization for fixtures may be obtained from the Illuminating Engineering Society (IES) Handbook, or from manufacturer's specifications. A medium maintenance factor shall be assumed. Spacing of fixtures shall not exceed IES recommendations. Fluorescent lighting shall, in general, be used in offices, shops, and other areas where high intensity, low brightness lighting is required. Incandescent fixtures may be specified for hallways, service areas, and auxiliary lighting. Mercury vapor lighting, or a combination or mercury vapor and other source may be considered for high-bay industrial areas.
b. High-voltage (480/277 volt) systems are usually more economical for larger installations and should be used wherever feasible. Switching may be accomplished by contactors, low-voltage control systems, or wall switches of sufficient voltage rating.

2. Footcandle Tables

The following illumination levels are taken from the IES Handbook for typical Hanford applications, and shall be used for design values. The Handbook lists recommended levels for many other industrial and commercial applications.

<table>
<thead>
<tr>
<th>Footcandles</th>
<th>DRAFTING ROOMS</th>
<th>EXTERIOR AREAS</th>
<th>INSPECTION</th>
<th>LABORATORIES</th>
<th>MACHINE SHOPS</th>
<th>OFFICES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Detailed drafting and designing</td>
<td>Entrance, pedestrian and/or conveyance</td>
<td>Ordinary</td>
<td>Work tables, general</td>
<td>Rough bench and machine work</td>
<td>Inactive files, washrooms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Storage areas and loading platforms</td>
<td>Difficult</td>
<td>Close work</td>
<td>Medium bench and machine work</td>
<td>Intermittent filing and conference rooms</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Very difficult</td>
<td></td>
<td>Fine bench and machine work</td>
<td>Regular offices - active filing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>LABORATORIES</td>
<td>Medium automatic machines, medium</td>
<td>Accounting, auditing, tabulating, bookkeeping,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>MACHINE SHOPS</td>
<td>buffing and polishing</td>
<td>business machine operation, rough layout</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fine bench and machine work, fine</td>
<td>Drafting</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>automatic</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>machines, medium grinding, fine</td>
<td>500*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>buffing and polishing</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Extra fine bench and machine work, grinding</td>
<td>1000*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* # See notes page 21
### Footcandles

**PAINT SHOPS**

- Dipping, ordinary hand painting, stencil and spraying: 50
- Fine hand painting and finishing: 100

**SERVICE AREAS**

- Corridors, elevators, and stairways: 20
- Locker rooms: 20
- Lounge rooms: 30

**STORAGE ROOMS AND WAREHOUSES**

- Inactive: 5
- Active:
  - Rough bulky: 10
  - Medium: 20
  - Fine: 50

**TESTING**

- General: 50
- Extra fine instruments, scales, etc.: 200*

**WOODWORKING SHOPS**

- Rough sawing and bench work: 30
- Sizing, planing, rough sanding, medium machine and bench work, and gluing: 50
- Fine bench and machine work: 100

### NOTES

* These high levels may be obtained with a combination of general lighting plus specialized supplementary lighting. Care should be taken to keep within the recommended luminance ratios. These seeing tasks generally involve the discrimination of fine detail for long periods of time and under conditions of poor contrast. The design and installation of the combination system must not only provide a sufficient amount of light, but also the proper direction of light, diffusion, and eye protection. As far as possible it should eliminate direct and reflected glare as well as objectionable shadows.

# Where conference rooms are also intended to be used for detailed work areas, the level should be increased to 100 footcandles.

* See the following page
NOTES (Continued)

Hallways, elevators, corridors, and interior stairways shall be lighted to a minimum of 20 footcandles (maintained) at the floor level but not less than 1/5 of the level in adjacent areas. Sharp contrasts in lighting levels between working space, hallways, and entrances should be avoided.

3. Brightness Ratio and Color

In the design of lighting systems of over 50 footcandles, it is necessary to maintain a comfortable luminance balance and avoid excessive reflected glare. These problems and their solution are discussed in the IES Handbook, Section 11. In general, light-colored, mat-finish wall and furniture surfaces should be used.

4. Emergency and Exit Lighting

a. Emergency lighting and power systems may be required for essential illumination and process loads. Emergency power may be supplied from the area emergency generating and distribution system or from a local generating or battery power source.

b. Illuminated exit lights must be installed over the main points of exit in large buildings.

c. In all cases, exit lighting circuits shall be connected ahead of the main service disconnecting devices. A separate switch or panel may be used for the exit lighting circuits and supplied from the emergency service if available.

5. Fixtures

a. A Lighting Fixture Schedule shall appear on the drawings. The fixture location reference symbol, and the type, quantity, voltage, and any other information necessary to clearly describe the fixture should be included.

b. Minimum IES values of illumination around electrical equipment shall be provided.

c. Fluorescent fixtures shall be of substantial mechanical construction to insure rigidity and accurate alignment. Hangers must be of adequate strength and securely attached to the supporting structure. Careful consideration should be given to the fixture construction so that relamping, cleaning, and other maintenance can be accomplished as easily as possible. Refer to paragraph 410-74 of the NEC for requirement that fluorescent light ballasts shall be installed at least 1-1/2 inches from combustible ceiling materials. See Standard E-14-20 for fluorescent fixture hanger assemblies and instructions.
d. Fluorescent lamp ballasts for indoor use shall be Class P (protected). Ballast performance shall meet the requirements of the American National Standards Institute (ANSI) Standard C82.1, Specifications for Fluorescent Lamp Ballasts, Section 4. When operated at normal load in an ambient air temperature of 40 ± 5°C, and at rated line voltage and frequency, the maximum temperature rise shall not exceed 65°C in the windings and 30°C in the capacitor. Ballasts shall be of the high power factor type, and shall operate at a power factor of 90 percent or higher. Ballasts shall have Underwriters' Laboratory, Inc. (UL) approval and be listed in the UL Electrical Construction Materials List. They shall be produced by a member of the Certified Ballast Manufacturers Association (CBM), and shall carry the CBM certification label.

e. Fixtures for industrial areas, both fluorescent and incandescent, shall conform strictly to the specifications of the RLM Standards Institute.

f. Other incandescent fixtures should be equipped with some form of lens, bowl, or other means to diffuse the light.

g. Incandescent lamps shall be rated at 120 volts. All exposed lamps shall be inside frosted. Fluorescent tubes shall be "Standard Cool White" color.

h. Exit lighting fixtures shall have plainly legible letters not less than 3/4 inches wide and 6 inches high. Fixtures shall have red translucent letters in an opaque field.

i. The location of safety showers shall be marked with a vapor-tight industrial fixture with green globe located a maximum of two feet above and three feet from the centerline of the shower head. The fixture shall be Crouse-Hinds V series or Type GRV, Form 100 with screw guard and VN72 green globe or approved equals. The fixture shall be located for maximum visibility in the area served by safety shower.

j. The metal parts of fixtures must be grounded to the conduit system or to grounding conductors. See paragraph C-3-s.

I. POWER SYSTEMS

1. General

a. Small power loads may be served from a lighting or combination service. A separate power system, i.e., service, feeder panels, or control centers, is required for large or numerous motor or other loads. See paragraphs under A-2 of this Criteria.
b. The recommendations as contained in the Institute of Electrical and Electronics Engineers (IEEE) Standard No. 141 "Electric Power Distribution for Industrial Plants" may be used as a reference in the design of power systems.

2. Indoor Transformer, Substation and Power Feeder Distribution Systems

a. Indoor substations must be designed and installed according to Article 450 of the NEC.

b. In general, standard unit substations should be located as near as possible to the center of the loads. Attached switchgear or motor control centers may be utilized. Simple radial distribution systems may be used or, where greater operating reliability is required, loop or network systems may be justified.

3. Switchgear

a. Metal enclosed switchgear for systems under 600 volts shall be in accordance with Hanford Standard Specification HPS-331-E.

b. Feeder distribution centers for 2400, 4160, or 13,800 volt systems shall be in accordance with Hanford Standard Specification HPS-335-E, Metal Enclosed Switchgear, 4.16 and 13.8 kV.

c. Circuit breakers shall have an interrupting rating sufficient for the short-circuit capacity of the system. Breakers shall be connected with line terminals to the line and load terminals to the load without exception.

4. Motors

a. The electrical power drawings must show motor locations and the horsepower of each motor. Where a large number of motors is required, it may be desirable to include a Motor Schedule on the drawings. Information as to the location, driven equipment, horsepower, speed, voltage, phase, enclosure, manufacturer's type, and the NEMA Code number shall be shown in the schedule.

b. NEMA Standard, general-purpose, squirrel-cage, induction motors shall be specified wherever possible. See Standard Specification HPS-355-E, Squirrel-Cage, Induction Motors, Fractional to 200 hp - 2300 Volts Maximum, for procurement of commonly used motors and the Instructions to the Specification for motor selection information. Special types and enclosures may be used where necessary. Synchronous motors should be considered for larger horsepower requirements. The cycling time of motors should be considered and motors derated as necessary.
c. Motors one-half horsepower and larger shall be three-phase. Motors 1/3 horsepower and smaller may be single-phase, 120 volts. Fractional horsepower motors 1/2 hp or larger shall be three-phase, 460 volt, except that fractional horsepower, capacitor-start motors may be used on single-phase, 240 volt systems in the absence of a 480 volt supply. Three-phase motors rated 1/2 to 10 hp, but not exceeding a total of 10 hp, may be connected to a 208 or 240 volt system if no 480 volt source is available. Motors rated 220 volts may be connected to 208Y/120 volt systems, but 230 volt motors cannot be used on 208 volts.

5. Motor Controllers
   a. Motor controllers, circuit protection, and disconnecting devices shall be designed and installed according to Article 430 of the NEC.
   b. Single-phase controllers may be the manual type with overload protection. Individual controllers for three-phase motors to 100 horsepower may be combination magnetic starters with over-current protection. Fused disconnect devices (30 ampere) shall be used with motors 3 hp and smaller. Cartridge fuses shall be of the nonindicating and nonrenewable type. Circuit breakers, rated in accordance with the NEC, shall be used with motors 5 hp and larger.
   c. Magnetic controllers shall be specified for use with all crane and elevator motors.
   d. Motor control overload relays of the manually reset type may incorporate either the bi-metallic or thin-film eutectic alloy heat sensitive elements.
   e. Motor control centers should be used in industrial buildings where the localized control of several motors is practical. Motor control centers shall consist of one or more standardized prefabricated metal sections completely enclosing the control equipment and assembled to provide a dead front unit. Control centers shall be in strict conformance with NEMA Standard No. IC5, Industrial Controls and Systems, and Hanford Standard Specification HPS-330-E, Motor Control Centers - 600 Volts.

6. Motor Control Circuits
   a. Control circuits shall, in general, be 120 volts a-c, supplied from an individual step-down transformer connected to the controlled power circuit. See Hanford Standard E-14-25 for other details.
   b. Control circuits and connections shall be clearly shown on the drawings. Control or other wiring diagrams involving complex electrical connections shall be drawn in detail (unless such diagrams are otherwise available). If necessary, a description of the desired operation of the equipment shall be included.
7. **Marking of Control Circuit Wiring**

All conductor marking, except in simple power and lighting systems where the several wire colors provide adequate identification, shall be marked by means of imprinted tubular white or yellow plastic wire markers placed at the conductor terminations. Markers shall be printed on a special typewriter with heated type bar.

8. **Indicator Lamps**

Color for remote indicating signal lamps for motors, switchgear and power operated valves are shown on Hanford Standard E-14-10.

9. **Power Operated Monorails, Cranes, Hoist, Etc.**

In the design of electrically operated mobile equipment, consideration shall be given to adequate personnel protection from energized trolleys and busways. If possible, equipment shall be specified with shielded or covered trolley conductors.

J. **HAZARDOUS LOCATIONS AND SPECIAL OCCUPANCIES**

1. **General**

Wiring methods for hazardous locations must be in strict accordance with Chapter 5 of the National Electrical Code. See also other NFPA Standards for the hazard classification of specific occupancies and conditions. No exceptions to those regulations will be permitted under any circumstances.

2. **Storage of Flammable Solvents in Refrigerators**

   a. Refrigerators used for the storage of flammable solvents in laboratories, shops, etc., shall be of special design with all internal sparking sources such as lights, switches, thermostat and solenoid either eliminated, removed from the interior storage area, or made explosion proof.

   b. Refrigerators located in areas where flammable solvents may be present in the air (Class I, Groups C and D locations) shall have all ignition hazards eliminated, both internally and externally, and shall have the Underwriters' Laboratory approval for use in those locations.

K. **STORAGE BATTERIES**

1. **General**

Storage batteries for ordinary applications (control of switchgear, emergency services, telephone exchanges, fire stations, etc.) shall be the lead-acid type. Nickel-iron or nickel-cadmium alkali batteries may be used in special cases where economically or otherwise justified.
2. **Installation**

a. Storage battery installations shall be designed according to Article 480 of the NEC. Separate battery rooms or enclosures are preferred for all installations.

b. Wiring for main battery leads shall be red, positive, and black, negative.

c. Positive ventilation must be provided at battery locations or in battery rooms. Air shall be exhausted at or near the ceiling. Such ventilation shall be separate from other building ventilating or air conditioning systems and shall be arranged to provide some natural ventilation in the event of failure of the battery ventilation system. A switch and pilot light for the ventilation motor should be located outside the battery room near the entrance, or in the immediate vicinity of unenclosed batteries, but not above the battery.

d. Lighting fixtures over batteries or in battery rooms shall be vapor tight and hung at least two feet below the ceiling.

e. Batteries should be installed on battery racks constructed for the purpose. Adequate clearance must be maintained around the battery for inspection and maintenance.

f. Battery rooms should preferably have concrete floors and a continuous concrete curb on all sides.

g. The walls of battery rooms for lead-acid batteries or other walls adjacent to batteries should be painted with an acid-resistant paint to a height of at least six feet.

L. **PROTECTIVE ALARM SYSTEMS**

Protective (burglar) alarm systems shall be designed and installed in accordance with AEC Manual Appendix 2401, Part III-A and Annex A. All designs shall be reviewed with the AEC Security Division. See also Hanford Design Criteria Section 7.8, Fire Alarm Systems.
STANDARD ELECTRICAL DESIGN CRITERIA
FOR
COMMUNICATION, SIGNALING, AND LOW-VOLTAGE
CONTROL SYSTEMS
STANDARD ELECTRICAL DESIGN CRITERIA

7.7 COMMUNICATION, SIGNALING, AND LOW-VOLTAGE CONTROL SYSTEMS

This section covers the general design requirements for all types of communication, low-voltage control, and signaling (except fire alarm) systems. Utility-owned telephone systems are included only to the extent that raceways, outlet boxes, grounding conductor, power receptacles, and space for terminal equipment shall be provided in permanent buildings (see Section C of this criteria). The term 'communication' as used herein includes all other control and signaling systems insofar as this criteria is applicable. These may be radiation alarms, security alarms, intercom systems, sound-powered telephones, etc.

A. GENERAL

1. The following shall be considered the basic codes for communication system design.


   b. The National Electrical Code, particularly Article 800.

   c. Aerial cable messenger attachments to poles are shown on Hanford Standards E-9-25. Use of Figure 8 aerial cable is shown on Standard E-9-30.

2. Other Hanford Standards and Guides which may be applicable to communications system design are as follows:

   HPS-359-E   Emergency Audible Alarm Signals
   SDC-7.2     Outside Lighting and Aerial Distribution Systems
   SDC-7.4     Underground Power Distribution Systems
   SDC-7.5     Interior Power and Lighting Systems
   SDC-7.8     Fire Alarm Systems

3. Drawings for communication systems shall show the location of poles, ducts, manholes, etc., by coordinates or by distance from
permanent markers. The layout, elevation, slope, and length of ducts shall be shown. All interior circuiting and the number of circuits in each run shall be clearly shown.

4. Except under unusual circumstances, power and communication cables shall not be run in common duct and manhole systems.

5. Telephone and communication cables shall not be run in ducts or tunnels with steam, water, or other piping unless the cables are mechanically protected from failure of the piping systems and unless measures have been taken to assure that the design ambient temperature at the cable locations will not be exceeded.

6. No other communications system wiring shall be installed in raceways in buildings used for telephone wiring.

B. SERVICES

1. The aerial communication services shall be attached to a building as near as practicable to the service pole. The point of attachment shall not be closer than two feet to any electric power or lighting service attachment.

2. A slack span in aerial services to buildings shall be provided. An eyebolt in the building wall shall be specified on which to terminate the cable messenger. Eyebolts shall have a 1-1/2 inch minimum diameter eye and be designed for a lateral load of at least 500 pounds. For drop wire services, a screw eye may be used. The eye shall have a minimum diameter of 1-1/2 inches and the screw shall withstand a lateral pull of 100 pounds.

3. Aerial drop wire or cable services shall be a minimum of 14 feet from grade to the point of attachment to the structure. Services over roadways, driveways, or service areas shall not be less than 20 feet above grade at any point. Mast arms attached to low buildings, or a pole set adjacent to the structure, may be used to meet these requirements. This paragraph does not necessarily apply to utility-owned services.

4. Galvanized, rigid, heavy-wall, steel conduit shall be provided for telephone or other service entrances. Except as below, the service conduit shall be continuous from the point of attachment, through the outside wall, to the terminal or protector box location. In frame buildings where the attic is accessible, a conduit sleeve through the outside wall may be used and a wooden runner installed in the attic to support the telephone drop wire or cable.
5. The conduit size for aerial or underground services is listed in the following table. For aerial services, an entrance cap shall be specified for use on 3/4 and 1 inch conduit. Larger sizes shall have insulated conduit bushings. A No. 12 Awg galvanized pull wire should be provided in all service runs.

<table>
<thead>
<tr>
<th>Size of Service Cable Pairs</th>
<th>Drop Wire</th>
<th>Size of Entrance Conduit Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 &amp; 16 up to 4 pairs</td>
<td>3/4</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>50 &amp; 75</td>
<td>1-1/2</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

C. TERMINATIONS AND PROTECTORS

1. The following paragraphs apply to all systems using telephone-type conductors. For utility-owned telephone systems, only the necessary space for terminal equipment shall be provided as covered in the following.

2. Utility room(s) should be provided in buildings having a high telephone density for termination of the communication services (telephone, control, alarm, etc.). Utility rooms shall be equipped with 120 volt AC outlets. A 3/4 inch plywood backboard shall be provided on one wall for mounting of equipment.

3. Protectors with fuses must be used where the outside cable is exposed to power-line potentials and where the entering cable conductors are No. 22 Awg or larger. Protectors without fuses may be used if the service cable is not exposed to power-line voltages or the entrance cable conductors are No. 24 Awg or smaller. The metallic shield of service cables, where used, must be grounded.

4. The service entrance cable to protector cabinet run shall be as short as possible.

5. Terminal cabinets shall be located to avoid terminal to outlet runs of over 150 feet.

6. Protectors for one or two individual lines may be installed indoors or outside on the building wall not more than nine feet above the ground. Protectors shall be fused and with surge arrester.

7. For three and four individual lines, a metal box shall be installed inside the building to house individual protector units. Minimum dimensions of the box shall be 10 inches high, 12 inches wide, and 3 inches deep. Box shall have a 1/2 inch plywood backboard and a hinged, latching cover.
8. Cable entrances of five or more lines shall terminate in a fuseless, protected terminal enclosed in a sheet metal housing for indoor installation.

9. Indoor, flush-mounted enclosures for terminals (not required in utility rooms) shall have a hinged, latching cover and a 1/2 inch plywood backboard. The minimum dimensions of the enclosure shall be as follows.

<table>
<thead>
<tr>
<th>Service Cable Pairs</th>
<th>Box Dimensions - Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Height</td>
</tr>
<tr>
<td>16 or less</td>
<td>30</td>
</tr>
<tr>
<td>25</td>
<td>36</td>
</tr>
<tr>
<td>50</td>
<td>56</td>
</tr>
</tbody>
</table>

10. A wood blackboard shall be provided for interior surface-mounted protectors. Overall dimensions shall be 12 inches greater than the protector(s).

11. Terminations of service entrance cable larger than 50 pairs will require special design.

E. GROUNDING

1. Terminals, protector equipment, and metal sheath of cables shall be grounded.

2. The grounding conductor shall be Type TW or THW, green color building wire not smaller than No. 12 Awg stranded copper, and shall be run directly to the grounding electrodes. Mechanical protection shall be provided if required.

3. The ground shall be a cold water pipe, if available, or a galvanized ground rod or rods to provide a resistance to ground of not more than 25 ohms. Underground conductors shall be bare, galvanized wire. Grounding assemblies are shown on Standards E-3-2 and E-3-4. If ground rods are used, a rod(s) separate from those for the power system shall be provided for communications systems, but all grounding systems shall be bonded together.

F. INTERIOR TELEPHONE RACEWAYS, CABINETS, AND OUTLETS

1. Approved raceways shall be provided in permanent buildings for installation of utility-owned telephone wiring and equipment. Raceways
may be rigid conduit, electrical metallic tubing, or other metal, wood, fiber, or plastic raceways designed for the purpose. Where rearrangement or alterations have been made to permanent buildings, or where additional instruments are required, telephone cable without raceways may be installed to branch terminal cabinets and for individual instruments in accordance with the telephone utility practice. However, raceways shall always be installed where mechanical protection is required.

2. Additional raceway capacity shall be provided in all runs of over three circuits on the basis of one spare circuit for each three live circuits.

3. Raceways for telephone or similar wiring shall be sized as follows.

<table>
<thead>
<tr>
<th>Number of Circuits - 2 Wire</th>
<th>Size of Cable - Pairs</th>
<th>Size Conduit or Equivalent Raceway Size - Inches*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 6</td>
<td>11 &amp; 16</td>
<td>3/4</td>
</tr>
<tr>
<td>7 to 10</td>
<td>25</td>
<td>1</td>
</tr>
</tbody>
</table>

* Larger size conduit is required for "key-type" telephone installations.

4. Junction boxes shall be utilized to combine converging raceways. Where several pairs connect to a cable, or where two or more cables are connected to a larger cable, a junction box or telephone cabinet shall be provided according to the following table for installation of connecting blocks by the telephone company.

<table>
<thead>
<tr>
<th>Number of Cable Pairs in Main Run</th>
<th>Standard Telephone Cabinet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 7</td>
<td>Flush</td>
</tr>
<tr>
<td></td>
<td>Surface</td>
</tr>
<tr>
<td></td>
<td>Use 4-11/16&quot; Outlet Box and Cover</td>
</tr>
<tr>
<td></td>
<td>14 x 18 x 4 12 x 18 x 4</td>
</tr>
</tbody>
</table>

5. Where the telephone wiring is in conduit, EMT, or other raceways, standard outlet boxes shall be specified. Boxes shall be furnished with standard telephone outlet plates. Metallic plates shall have an insulated grommet or bushing. Outlets shall be located within five feet of each instrument location and 18 inches above the floor, unless otherwise specified.

G. RADIO COMMUNICATION

1. Radio transmission equipment shall not be procured, developed, or modified until after a frequency for the intended use has been authorized, or until being assured that the authorization is forthcoming.
2. Requests for a frequency assignment shall be made to the Commission. Generally, 60 days should be allowed for processing the request.

3. Certain frequencies have been designated for AEC use by the Director of Telecommunications Management (DTM). Use of citizen's band frequencies by AEC contractors is not permitted.

4. For detailed information and requirements, see AEC Manual Appendix 0270, Telecommunications Services Handbook, Part IV, Radio Services. All questions concerning radio equipment shall be referred to the Commission.
STANDARD ELECTRICAL DESIGN CRITERIA

FOR

FIRE ALARM SYSTEMS

This Section consists of 15 pages.
7.8 FIRE ALARM SYSTEMS

A. GENERAL

1. Fire alarm systems shall be designed and constructed in accordance with the following National Fire Protection Association (NFPA) publications.

   a. NFPA 72A - Local Protective Signaling Systems (National Fire Codes Vol. 7)
   b. NFPA 72B - Auxiliary Protective Signaling Systems (National Fire Codes Vol. 7)
   c. NFPA 73 - Municipal Fire Alarm Systems (National Fire Codes Vol. 7)
   d. NFPA 70 - National Electrical Code (National Fire Codes Vol. 5)
   e. NFPA 13 - Sprinkler System Installation (National Fire Codes Vol. 6)

2. The recommendations in the foregoing NFPA publications where prefaced by the word "should" shall be interpreted as mandatory unless there is good and sufficient reason why those recommendations cannot be adhered to.

3. The word "municipal" as used in NFPA Publications Nos. 72 and 73 and in this Design Criteria shall be construed to refer to a group of manufacturing, warehouse, or office buildings which comprise a separate "area" or group of areas at Hanford.

4. Fire alarm equipment for new installations at Hanford must have reliable and dependable operating characteristics and be compatible with that used in existing systems.

5. Equipment for additions to existing fire alarm systems shall preferably be of the same manufacture and type as the existing equipment. Apparatus of substitute manufacture must be operable and compatible with the existing equipment.

6. The word "approved", as applied to fire alarm equipment in this Design Criteria, means tested by the Underwriters' Laboratories or the Factory Mutual Laboratories and found suitable for installation and use for the specific application.

7. The term "an approved equal" as applied to manufacturers' products
referred to in this Design Criteria shall be understood to include
the provisions of the foregoing paragraphs (4, 5, and 6), and
that which is acceptable to the U.S. Atomic Energy Commission,
RL, hereinafter referred to as the Commission.

B. FIRE STATION SYSTEMS

1. Requirements

a. The general purpose of a fire alarm system is to detect a
fire in the early stages, and to sound an alarm to building
occupants and at the fire station.

b. Fire alarm systems consist of one or more metallic loop
circuits originating at the fire station with several municipal
fire alarm boxes or master fire alarm boxes connected into
each circuit. A current of approximately 100 milliamperes
is maintained in each circuit by means of the fire station
power supply.

2. Fire Station Equipment

a. Existing area fire alarm systems at Hanford are the Type B
(automatic retransmission) systems as defined in NFPA No. 73,
Section 1220.

b. Fire station equipment for multiple box circuit systems shall
be of sufficient quantity and capacity to receive, announce
visibly and audibly, and record alarms and other signals from
box circuits. Fire station equipment shall include a watch desk
with audible sounding device, a spring-motor driven or
electrically-driven register, one or more large electro-
mechanical fire alarm gongS, and traffic warning signals
and controls as required.

c. In some cases it may be necessary to provide for the transmission
of a coded signal to a remote location over a telephone circuit
which will require additional recording equipment at the remote
point.

d. A line terminal and protector cabinet with fuses shall be re-
quired in fire station buildings for incoming box and other
signal circuits. The cabinet shall be located as close to the
point of entrance as possible. Circuit protection equipment
and installation shall comply with the requirements of
NFPA No. 73, Article 220. Gas-filled arrestors shall be used.

e. The protector cabinet shall be grounded by means of a No. 8 Awg copper conductor, mechanically protected, run to the water piping system. If no existing ground is available, a separate grounding electrode shall be provided for fire alarm protector cabinets. Copper conductors shall not be installed in direct contact with the earth. See paragraph B-5-c for grounding standards.

3. Station Battery

a. The normal battery voltage will depend on the external resistance of the circuit and shall be at least 50 percent in excess of that required to maintain a current of 100 milliamperes in the circuit. A variable resistance is used to adjust the current to this value. Batteries may be 48, 72, or 120 volts as required by the above.

b. Where only a single source of charging current is available, the battery capacity shall be sufficient to maintain a current of 100 milliamperes in the circuit for a minimum of 60 hours. If an emergency source is available for charging, the capacity shall maintain the service for 24 hours.

c. The battery installation shall conform to the NFPA No. 73, Section 2330 and 2340, the National Electric Code, and Hanford Design Criteria, Section 7.5.

d. Sufficient space shall be reserved at battery locations for additional batteries for future box circuits.

4. Municipal Fire Alarm Boxes

a. Boxes shall be weatherproof, shall be of the noninterfering and succession type, shall be of a distinctive size and shape and finished in "signal red" color, and shall conform to requirements of NFPA No. 73, Article 240. Boxes shall operate on the ground circuit return if the loop circuit is interrupted. Four coded rounds of the signal shall be transmitted on an alarm. The Commission will furnish wheel coding upon request of the installing Contractor.

b. Fire alarm boxes shall be conspicuously located, preferably at street intersections or near the main entrance of buildings to be equipped with fire protection systems. General illumination
of the area around fire alarm boxes shall be provided by either a street luminaire or floodlighting.

c. Each outside alarm box installation must include a red light located above the box to indicate its location. For pole or wall mounting, specify Crouse-Hinds Vaportight Fixture no. VDA175 for 1/3 inch conduit and feed from above, VN75 red glass globe, and V911 guard, or approved equals. This assembly is also available from Gamewell under Cat. No. 7511. Pole mounted lights shall be installed a minimum of 18 inches from the pole directly above the box. The red indicating lights shall preferably be energized from a local street-lighting circuit where available, or lights may be supplied as described in NFPA No. 73, paragraphs 2372 and 2373.

d. The area served by each circuit should be planned with regard for natural boundaries such as principal streets, and as specified in NFPA 73, paragraph 2023 (a). Provision for future expansion within each protected area should be considered. A maximum of 40 street or master boxes may be included for special hazards (auxiliary systems), provided the physical area covered by the circuit is not increased.

e. Pole-mounted alarm boxes and fire alarm circuits must be installed in accordance with Hanford Electrical Standards, Section E-9, as applicable. Suitable brackets should be used to attach alarm boxes to poles.

f. Metal pedestals may be used for mounting boxes.

g. The operating handle of boxes shall be installed five feet from grade.

5. **Grounding**

a. It is particularly important that each fire alarm box is well grounded, since, in addition to the protection of personnel and equipment, the ground path is utilized to conduct the alarm signal in the event that either of the metallic loop conductors is disabled.

b. Fire alarm boxes shall be grounded, except as in paragraph (d) below, by means of a 3/8 inch diameter by five foot copper clad conductor extending from the box to the ground level.
c. The equipment shall be grounded to an existing water line or grounding mat, if available with 100 feet from the box. In the absence of a water line within this distance, the ground may consist of two or more ground rods, or other approved grounding methods, so that the resistance to ground does not exceed 25 ohms during the dry season. See Hanford Standards E-9-1 and E-9-2, and DI-E-9-1 and 2 for detailed methods and instructions.

d. Underground conduits to fire alarm boxes or master boxes may be installed for the fire alarm service conductors or the interconnection between a master box and auxiliary equipment located in buildings. In such cases the conduit may be used as the box ground provided that the conduit is properly grounded as in the previous paragraph 'c', and that a suitable ground wedge or bushing is used in the box with a jumper connected to the box ground post.

e. Isolated conduits to red indicating lights must be grounded.

f. See also the foregoing paragraph B-2-e for grounding of protector cabinets.

6. **Wiring**

a. Construction for aerial fire alarm circuits shall meet the National Electrical Safety Code requirements for medium loading.

b. Pole-mounted lightning arrestors are required for open-wire fire alarm circuits at intervals of approximately 2000 feet, at junction points of open wire to cable, and between aerial and underground cables. Arrestors shall be Cook Electric Co. outdoor/indoor fuseless protector, No. 500G-P for one pair with Type C-350 FS, fail-safe gas arrestors, or an approved equal. The installation of lightning arrestors in fire alarm boxes is not recommended. Arrestors shall be grounded and should be installed on poles at box locations, where possible, so that a single ground connection can be utilized.

c. Overhead fire alarm conductors should be routed to permit the circuit to be traced easily.

d. Overhead fire alarm conductors must not be attached to cross-arms which carry lighting or power conductors. A minimum vertical clearance of two feet from insulated secondaries up to 750 volts and high-voltage cables having a grounded messenger
shall be maintained. A minimum of four feet clearance is required between open-wire power lines and fire alarm conductors.

e. The split-bolt type connectors shall be used for all taps and splices in overhead wiring.

f. Where subject to mechanical injury, fire alarm conductors and cables must be enclosed in rigid metallic conduit. Conductors for vertical runs from boxes to overhead conductors shall have 600 volt insulation, be approved by NFPA No. 70 for wet locations, and shall not be smaller than No. 12 Awg.

g. Direct-burial cables or single conductors shall be installed in accordance with NFPA No. 73, paragraph 2136. Single conductors shall be extra heavy wall (78 mils) thermoplastic insulated wire not smaller than No. 8 Awg.

h. Fire alarm circuits may be run in cable with or without other services if installed according to the provisions of NFPA No. 73, Article 210.

i. See Hanford Electrical Section E-9 for aerial fire alarm circuits.

C. AUXILIARY FIRE ALARM SIGNALLING SYSTEMS

1. General Requirements

a. Auxiliary systems consist of electrical circuits and associated instruments and devices having their operation under the control of the occupants of a separate building.

b. The design of auxiliary fire alarm systems shall conform to NFPA No. 72B and the following paragraphs of these Design Criteria.

c. Auxiliary fire alarm systems shall, in all cases, include a master fire alarm box connected to the fire station-loop circuits, so that the activation of an alarm element in the auxiliary system will initiate an alarm at the fire station. All types of fire detector and automatic extinguishment devices may be connected into the auxiliary system.

d. Shunt-type auxiliary systems (where energy is provided by the fire alarm loop circuit) shall be limited to one zone of manual alarm boxes or waterflow devices. Larger installations shall have a separate local power supply. See NFPA No. 72B, Section 1016, for a detailed discussion of local energy and shunt-type auxiliary systems.
2. **Master Fire Alarm Boxes**
   
a. Master boxes shall be of the same general specification as for municipal boxes, paragraph B-4-a of these Design Criteria.
   
b. Master boxes shall be mounted adjacent to or in the entranceway or foyer of the protected building but not within the building. Boxes may be flush or surface mounted. The mounting shall be rigid. Sheet metal or other unsubstantial walls shall be adequately reinforced at the box location. A metal backing plate or other leveling device shall be used over corrugated, shake, or irregular wall surfaces.
   
c. The red indicating light, the mounting height, grounding, and wiring as specified for municipal boxes shall also apply to master box installations.
   
3. **Auxiliary Fire Alarm Boxes**
   
   
b. Auxiliary boxes shall be equipped with one set of normally closed or normally open contacts for the alarm circuit, depending on the control panel circuitry. Switches shall be the positive contact type (not the mercury tube type).
   
c. Auxiliary boxes in wholly manual systems shall be located in accordance with NFPA No. 72B, paragraph 3113, and the following. Fire alarm boxes shall be installed at each major building exit and stairwell on each floor in multi-story buildings. Shop buildings shall have one box at each floor level and one additional box for each maximum section of 7500 square feet. Auditoriums shall have one box located in the projection room, one at each side of the stage, and one in the lobby as the minimum requirement.
   
d. Boxes shall be mounted so that the operating handle is five feet above the floor. They shall be securely attached to the supporting structure.
   
4. **Control Panels and Annunciators**
   
a. A control panel shall provide the following functions as specified in the supplemental criteria.
(1) Trip the master fire alarm box which will transmit a coded signal to the fire station.

(2) Operate the fire alarm gongs to alert the building occupants. See Section C-5.

(3) Provide zone annunciation. Annunciators shall be the lamp type, shall reset automatically when the control panel is reset, and shall have a lamp-test pushbutton circuit. Annunciator panels shall be located near to and within sight of the master box and may be flush or surface mounted. There shall be at least one annunciator lamp for each floor or each fire zone of the building. Annunciation from auxiliary boxes shall show the same fire zone as that from the surrounding detector system.

(4) Provide annunciation for additional future zones (spares) in accordance with the growth potential of the building.

(5) Activate a ventilation supply fan shutdown control on a fire alarm. Supply fan circuits shall not be reactivated until the fire alarm control panel is reset. Exhaust fan circuits shall be provided with a manual, key-operated, by-pass switch to permit continued operation during emergencies. The by-pass switch shall be located in or near the annunciator panel. The key shall be locked in when the switch is in the by-pass position.

(6) Electrical circuitry shall be supervised as per NFPA No. 72B, Article 240. A trouble signal shall be initiated and transmitted to the fire department or other location acceptable to the Commission, but such circuitry shall not interrupt a fire alarm or prevent an alarm from being transmitted. The term "trouble signal" is defined in Article 100 of NFPA No. 72A. Accessible jacks shall be provided for checking and measuring the supervisory current.

(7) The control panel shall require manual resetting.

(8) The power supply shall be rechargeable batteries with all necessary recharging facilities and devices. The batteries shall be sized to operate the system for at least 60 hours after loss of charging current and be capable of transmitting a fire signal at the end of this period. The failure of ac charging power shall not cause a false alarm but shall cause a trouble signal to be transmitted to the fire department or other location acceptable to the Commission upon a drop in battery voltage to 75 percent.

(9) Provide complete supervision of sprinkler systems including, but not limited to, post indicator valves, sectional control valves and air supply for dry systems. Trouble signals and supervisory signals may be transmitted as the same signal, but must provide a separate and distinct alarm from fire to a remote location acceptable to the Commission.
The term "supervisory signal" is defined in NFPA 72A, Article 100.

(10) Terminal blocks for connection of all external wiring to the control panel shall be furnished.

(11) A fire alarm drill test switch to actuate the single-stroke gongs (but not the supply fan shutdown control) shall be included.

(12) All fire alarm controls shall be housed in one key-locked control cabinet. Pilot lights shall be exposed and adequately identified.

b. Supervisory or control panels shall be used with shunt-type systems only where necessary for local alarm and/or fan shutdown functions.

c. All relays, switches, and devices in the control panel shall be mounted to prevent false operation or failure of any component due to vibration or shock. Sealed relays are preferred. If contacts are exposed, they shall be in a vertical plane to minimize dust accumulation.

d. The control panel shall be installed in the building entrance-way or foyer as close to the master fire alarm box as possible. Interconnecting conductors shall be enclosed in heavy-wall metallic conduit. See SDC-7.5 for use of conduit. The control panel may be surface or flush mounted.

e. The emergency battery compartment shall be properly vented and painted with an electrolyte corrosion-resistant paint. See NFPA No. 72B, paragraph 2232 and 33 for battery location and mounting.

f. Door locks shall be provided for all control cabinets, annunciator panels and battery compartments. Locks furnished with this equipment shall be limited to types which can be opened with any one of the following keys.

(1) Corbin Cabinet Lock, Division of Emhart Corp. - Key No. CAT 60.

(2) Eagle Lock Corporation - Key No. H700.

(3) The Illinois Lock Company - Key No. G 332.

(4) Yale Lock & Hardware Division, Eaton Yale & Towne, Inc. - Key No. CH 930.
5. Local Fire Alarm Gongs

a. Local audible fire alarm equipment shall be located in accordance with NFPA No. 72A, paragraph 2510.

b. Sounding devices shall be single-stroke gongs. A cycling timer is required to produce intermittent current to the gongs at 1/2 second intervals. The timer may be incorporated in the control panels as described above. See Hanford Standard HPS-359-E, Emergency Audible Alarm Signals, for requirements and DI-359-E for suggested equipment.

c. Single-stroke gongs shall be 6" or larger, indoor type, or weather-tight depending on the application, and must be sufficient in number and intensity to produce a sound level of at least 10 db above maximum expected background noise.

6. Automatic Fire Detectors

a. In general, automatic detection shall be installed wherever sprinklers would have been required if the building were of sufficient value to merit a sprinkler system. See NFPA 13, paragraph 3650 for temperature ratings, and Part D of these Criteria for location of fire detectors.

b. Automatic detectors must be listed by Underwriters' Laboratories and shall be sufficiently sensitive to be listed for at least 30 foot spacing. In certain instances, detectors that do not meet this criteria may be desirable, but their use at an individual location must be approved by the Commission. Detectors shall conform to published Underwriters' Laboratories Standards.

c. Care shall be taken to locate rate-of-rise detectors in the path of natural drafts to aid in more prompt detection. Similarly, to avoid faulty operation, they should be located out of the path of forced drafts or the direct rays of the sun.

7. Combustion Products and Smoke-Actuated Detector Heads

Combustion product detectors and smoke-actuated detectors are not synonymous. Though listed as smoke detectors by Underwriters' Laboratories, combustion product detectors are "responsive to both gaseous products of combustion and smoke." They might be more correctly described as "High Sensitivity Smoke Detectors" or "Early Warning Devices" because they respond to incipient products of combustion formed long before visible smoke is generated. Smoke detectors respond to visible smoke only. Combustion-products
detectors should be provided with a normal and an emergency power supply.

8. Eutectic Tube Detectors

Eutectic tube detectors are continuous line thermostats consisting of a wire insulated by a eutectic salt from an outer metal shell. When heated, current flows between the wire and the shell. Though not listed by Underwriters' Laboratories, this system is acceptable under certain circumstances where approved by the Commission.

9. Special Detectors

In many instances, specific types of detectors such as pneumatic, thermopile or others may be used where applicable and where approved by the Commission.

10. Automatic Sprinkler Valve Equipment

a. Approved equipment is required for use with wet or dry pipe sprinkler valves to supervise the operation and automatically initiate a fire alarm upon the opening of any sprinkler head in the system. Such equipment shall be designed and installed according to NFPA No. 72B, Article 330.

b. Sprinkler alarm valve circuit openers may be connected directly to a master fire alarm box. Or the circuit openers can be connected into an auxiliary fire alarm system which may include other sprinkler valves or other auxiliary activating elements, provided that an annunciator is included with an indicating position for each element or zone of the auxiliary system. Surge protection by a positive pressure pump shall be provided for all wet-pipe sprinkler systems.

c. At least one auxiliary box shall be included in sprinkler alarm systems for manual operation.

11. Wiring

a. Wiring for auxiliary fire alarm systems shall comply with NFPA No. 70, Hanford Design Criteria 7.5, and the following:

(1) All splices in fire alarm wiring shall be made mechanically strong, soldered and taped, or pressure-type solderless
connections and terminal lugs may be used. Connectors shall be installed according to the manufacturer’s instructions and with the proper tool for the connector or terminal.

(2) Conductors for interior, auxiliary fire alarm circuits may be No. 14 Awg minimum size and shall be 7 strand copper wire.

b. Wiring may be installed in heavy-wall rigid conduit, electrical metallic tubing or nonmetallic sheathed cable (except for the requirement in paragraph C-4-d), depending on the type of building construction and occupancy. Special cables and cables for limited-energy systems may be used subject to the provisions of NFPA No. 72B, Article 210. All wiring and cables in permanent laboratory, shop, process, and storage areas shall be run in heavy-wall conduit or EMT. Cables may be used without conduit in the concealed spaces in the building construction of administration areas.

c. Electrical power for local control panels, annunciator and sounding devices shall preferably be obtained from a separate lockable service panel (exit light panel) connected ahead of the building lighting service disconnecting device, or if no such panel is available, a separate breaker in a lighting panelboard may be used. The breaker shall be fitted with a suitable guard requiring the removal of a screw to open. The breaker shall be painted red and shall serve the fire alarm equipment only. The fire alarm power circuits shall be automatically connected to the emergency power sources if available.

d. Each wire and each zone of fire alarm loop circuits shall be identified with adhesive wire markers or by color coding in each detector head box, each auxiliary device box, each junction box, and at control panels. Colored tape may be used if the circuits are identified at each of the foregoing locations. Where wire insulation or tape color coding is employed, each loop circuit shall be the same color throughout and a different color shall be used for each loop. Green and white color wire or tape shall not be used for loop circuit identification.

e. Boxes for detector heads shall be a minimum depth of 2-1/8 inches.

f. The covers of all junction boxes and terminal boxes in an auxiliary alarm system shall be painted red for easy identification. Enclosures for fan-shutdown relays, test panels, or other equipment associated with fire alarm systems, shall be painted with red
enamel and shall have one inch high letters "F.A." painted in white on the cover where such enclosures are not specifically manufactured and finished for fire alarm service.

g. All relays, switches, pushbuttons, fuses, pilot lights, terminals, terminal boards, etc., in the control and annunciator panels shall be marked and identified and properly coordinated with the nomenclature on the drawings.

h. A wiring diagram showing the physical location of each identified device, the wire identification code, and all interconnections; and a scale drawing of the entire fire alarm system as installed shall be attached to or inserted in a pocket on the inside of the control panel door.

D. DESIGN AND INSTALLATION OF AUTOMATIC DETECTION SYSTEMS

1. General

a. The following recommendations are included to aid in the design, installation, and inspection of automatic fire alarm systems. The use of unlisted fire alarm devices and materials will require approval of the Commission.

b. Fire alarm drawings must show the general construction, type of ceiling, location of fire walls, location of all partitions, and the size and location of closets, fixed benches and tables, and other areas of a questionable nature where detection may be required.

c. Fire detectors shall be installed in locations and in accordance with the requirements of NFPA 13 for sprinkler heads except that the spacing of detectors shall be in accordance with the Underwriters' Laboratories "Fire Protection Equipment List." In general, automatic fire detectors shall be installed throughout all areas of a building including basements, attics, lofts, and all combustible spaces.

d. In existing buildings, fire alarm equipment can frequently be saved by minor remodeling such as elimination of unnecessary ceilings, opening hollow spaces in walls and enclosed spaces over shelving, partitions, and decks. The open slatting of decks and walkways as a substitute for installation of detectors underneath is not considered to be a good practice.
2. **Spacing of Detectors**

   a. Tight, solid beams and similar obstructions over 18 inches down from the ceiling which would obstruct the flow of heat to detectors shall be treated as full walls or partitions.

   b. For panel construction (beams and girders framed into each other forming definite bays or heat pockets), the detector spacing shall be reduced. It is felt that, under most circumstances, a reduction in spacing of 3/4 of that shown in the UL listings is acceptable.

   c. No reduction is required for open bar joist construction (small lightweight truss members forming no appreciable obstruction to the heat passage). For open joist construction consisting of members spaced within three feet of each other, whether of reinforced pan-type or ordinary wood joists, the spacing of detector heads shall be reduced 50 percent measured at right angles to the joists.

   d. Where of necessity, automatic detectors are installed below the maximum allowable distance from the roof or ceiling, heat collectors made of sheet metal immediately over the detectors shall be provided. These heat collectors shall be at least 18 by 18 inches with a one-inch drop lip.

   e. Detectors shall be located within two feet (measured vertically) of the apex of pitched roofs having a pitch in excess of 1 in 3. The distance between detectors under pitched roofs shall be measured parallel to the roof slope.

   f. Girders or beams, forming narrow pockets along walls of combustible construction where of a depth which will trap heat, may require additional detectors.

3. **Blind Spaces and Small Enclosures**

   The location of fire detectors in blind spaces shall be in accordance with NFPA 13, paragraph 4305, except for spacing. The Commission shall be consulted in the event of unusual conditions.

4. **Other Detector Location Requirements**

   a. Detectors shall be installed under awnings or roofs over outside platforms except where the construction is noncombustible and the platform contains no combustibles.

   b. Detectors shall be installed under decks, galleries, ductwork.
and other horizontal flat surfaces that exceed four feet in the minimum dimension.

c. Detectors shall be installed under exterior docks and platforms of combustible construction unless such space is closed off and protected against the accumulation of windborne debris.

d. Where overhead doors are normally left open during a major part of the work day, detection may be required below.

e. Detectors may be required under open work tables or stock shelving wider than five feet unless tight partitions of noncombustible material not over 10 feet apart are provided underneath the tables or shelving. Partitions must be the full width of the unit extending from the underside of the top surface to the floor and shall be substantially fastened. Tables and shelving up to 10 feet in width can be treated this way by partitioning through the middle to form units that do not exceed 5 by 10 feet.

5. Types of Detection Recommended

a. For high-valued, high-susceptibility equipment, prompt fast-acting products of combustion detectors (early warning devices) should be installed. Included are computer rooms, control rooms, high-valued electrical equipment rooms, and areas of particular sensitivity to production operations.

b. In low-value buildings which do not justify automatic sprinkler protection, less costly automatic fire detection may be used. Continuous line thermostat wire may be the most economical and may be used where the wire is not subject to mechanical damage.

c. Ordinary spot thermostats are usually acceptable for offices and other personnel areas.

d. For chemical hoods, gloved boxes, and similar enclosures, the Fenwal "Detect-a-fire" is preferred.
SDC-7.10

STANDARD ELECTRICAL DESIGN CRITERIA
FOR
CORROSION PROTECTIVE SYSTEMS

This Section consists of 11 pages.
7.10 CORROSION PROTECTIVE SYSTEMS

A. GENERAL PRINCIPLES

1. Galvanic Corrosion

Galvanic Corrosion may be defined as accelerated electrochemical corrosion produced when one metal is in electrical contact with another more noble metal, both being in the same corroding medium, or electrolyte. Corrosion of this type usually results in a higher rate of solution of the less noble metal and protection of the more noble metal. During the corrosion process an electric current is generated by the two metals in contact, the magnitude of this current being equal to the acceleration of the corrosion of the more vulnerable material beyond its normal extent. The general reaction is similar to that of a cell, or battery, from which a definite amount of electrical power may be derived.

2. Galvanic Series

It is possible to set up a series which will indicate the tendencies of metals and alloys to form galvanic cells and to predict the probable direction of the galvanic effects. Such a series for commonly used materials is shown in the following Table. This series is not to be confused with the theoretical "Electromotive Series". Metals that are closely grouped in the Table have no strong tendency to produce galvanic corrosion of each other, and from the practical standpoint are relatively safe to use in contact with each other. The coupling of two metals distant from each other in the list will result in galvanic, or accelerated, corrosion of the one higher in the list. The farther apart the metals stand, the greater will be the galvanic tendency, as may be determined by measurement of the electrical potential difference between them. The potentials shown in the Table are approximate and will vary with each corrosive condition. What actually determines galvanic effect is the quantity of current generated rather than the potential difference.
The chromium-iron and chromium-nickel-iron alloys (stainless steels) frequently change positions, as indicated, depending upon the corrosive media, particularly with respect to its oxidizing power and acidity or to the presence of activating ions such as halides. The positions occupied may be anywhere between the extremes indicated.

**GALVANIC SERIES OF METALS AND ALLOYS**

**POTENTIALS TO**

**A SATURATED COPPER-COPPER SULFATE HALF-CELL**

<table>
<thead>
<tr>
<th>Material</th>
<th>Potential (volts, negative)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium (anode alloy)</td>
<td>1.75</td>
</tr>
<tr>
<td>Magnesium (commercial)</td>
<td>1.55</td>
</tr>
<tr>
<td>Zinc</td>
<td>1.10</td>
</tr>
<tr>
<td>Aluminum (Alclad 3S)</td>
<td>1.01</td>
</tr>
<tr>
<td>Cast iron</td>
<td>0.68</td>
</tr>
<tr>
<td>Carbon steel</td>
<td>0.68</td>
</tr>
<tr>
<td>Stainless steel, type 430, 17% Cr (active)</td>
<td>0.64</td>
</tr>
<tr>
<td>Ni-resist cast iron, 20% Ni</td>
<td>0.61</td>
</tr>
<tr>
<td>Stainless steel, type 304, 18% Cr, 8% Ni (active)</td>
<td>0.60</td>
</tr>
<tr>
<td>Stainless steel, type 410, 13% Cr (active)</td>
<td>0.59</td>
</tr>
<tr>
<td>Ni-resist cast iron, 30% Ni</td>
<td>0.56</td>
</tr>
<tr>
<td>Ni-resist cast iron, 20% Ni + Cu</td>
<td>0.53</td>
</tr>
<tr>
<td>Naval rolled brass</td>
<td>0.47</td>
</tr>
<tr>
<td>Yellow brass</td>
<td>0.43</td>
</tr>
<tr>
<td>Copper</td>
<td>0.43</td>
</tr>
<tr>
<td>Red brass</td>
<td>0.40</td>
</tr>
<tr>
<td>Bronze</td>
<td>0.38</td>
</tr>
<tr>
<td>Admiralty brass</td>
<td>0.36</td>
</tr>
<tr>
<td>90-10 Cu-Ni + 0.8% Fe</td>
<td>0.35</td>
</tr>
<tr>
<td>70-30 Cu-Ni + 0.06% Fe</td>
<td>0.34</td>
</tr>
<tr>
<td>70-30 Cu-Ni + 0.47% Fe</td>
<td>0.32</td>
</tr>
<tr>
<td>Stainless steel, type 430, 17% Cr (passive)</td>
<td>0.29</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.27</td>
</tr>
<tr>
<td>Stainless steel, type 316, p8% Cr, 12% Ni, 3% Mo (active)</td>
<td>0.25</td>
</tr>
<tr>
<td>Inconel</td>
<td>0.24</td>
</tr>
<tr>
<td>Stainless steel, type 410, 13% Cr (passive)</td>
<td>0.22</td>
</tr>
<tr>
<td>Titanium (commercial)</td>
<td>0.22</td>
</tr>
</tbody>
</table>
### Potential - volts, negative

<table>
<thead>
<tr>
<th>Metal/Alloy</th>
<th>Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silver</td>
<td>0.20</td>
</tr>
<tr>
<td>Stainless steel, type 304, 18% Cr, 8% Ni (passive)</td>
<td>0.15</td>
</tr>
<tr>
<td>Hastelloy C</td>
<td>0.15</td>
</tr>
<tr>
<td>Monel</td>
<td>0.15</td>
</tr>
<tr>
<td>Stainless steel type 316, 18% Cr, 12% Ni, 3% Mo (passive)</td>
<td>0.12</td>
</tr>
</tbody>
</table>

3. **Factors Influencing Galvanic Corrosion**

The galvanic series indicates only the tendency of the several metals and alloys to set up galvanic corrosion. Actual corrosion cannot proceed unless there is a flow of electrical current. As in the case of ordinary corrosion, the ease with which this current can flow, and the magnitude of the current, are controlled by basic factors, the most important of which follow:

### a. Conductivity of the Circuit

There must be a complete circuit through the conducting metals and the solution. In view of the relatively low voltages involved, contact between the two (or more) metals must be good. Practically, it has been demonstrated that the contact must be metal-to-metal and entirely through a metallic path. Then the total resistance of the circuit is usually controlled by the resistance of the solution. In the case of tap water and other relatively low-conductivity solutions, the galvanic influences are usually localized so that the less-noble metal (the anode) suffers most of its accelerated corrosion in a region in the immediate vicinity of the more-noble metal (the cathode). Strong salt solutions (such as brines and sea water) and strong solutions of other chemicals including acids and alkalies are very good conductors, and galvanic corrosion is more likely to be distributed widely over the entire anode surface. Thin films of condensed moisture, if dissolved salts or ionizable dissolved gases are present, may complete the circuit and galvanic corrosion will occur, although corrosion tends to be localized near the points of contact.
b. Polarisation

The effective potential difference between the anode and cathode may be reduced considerably by polarization, which may occur at the anode through the accumulation of corrosion products (metallic ions which reduce the anode potential) or at the cathode through the deposition of hydrogen.

General experience has shown that the accumulation of hydrogen, or cathodic polarization, is most often of controlling importance. If hydrogen is not removed from the cathodic surfaces, the electromotive force of the galvanic cell may fall to very low values and galvanic corrosion will approach zero. Dissolved oxygen is the most common and one of the most potent depolarizers. If present, it will unite with the deposited hydrogen to form water, and the galvanic forces will continue to operate.

Cathodic depolarization is frequently of such influence on galvanic corrosion that the total corrosion of the anodic material is practically independent of the cathodic material—provided, of course, that the two metals stand definitely apart in the galvanic series. For example, iron in contact with copper, bronze, brass or Monel is corroded at substantially the same rate.

c. Relative Cathode and Anode Areas

The ratio of exposed area of the corroding material to that of the protected material does not influence the initial difference in potential between the two. However, the quantity of current that is generated and the acceleration of corrosion associated with this current depend largely upon that ratio. A small anode and a large cathode tend to result in an increase in current density (a concentration of current on the anode), with a subsequent great increase in corrosion rate.

Several investigations have shown that the increased corrosion of the anode above its normal rate in a good electrolyte is almost linearly proportional to the ratio of the sum of the areas of the anode and cathode and the area of the anode.

d. See page 11 for chart showing degree of galvanic corrosion to be expected at bimetallic contacts.
e. See reference 1, paragraph F of this criteria, for information concerning caustic embrittlement, cavitation erosion, corrosion fatigue, crevice corrosion, dezincification, graphitization, hydrogen embrittlement, intergranular corrosion and stress corrosion.

B. UNDERGROUND CORROSION

1. The theoretical weight loss per ampere per year for several metals commonly used underground are shown in the following table.

<table>
<thead>
<tr>
<th>Metal</th>
<th>Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Steel</td>
<td>20</td>
</tr>
<tr>
<td>Lead</td>
<td>75</td>
</tr>
<tr>
<td>Copper</td>
<td>46</td>
</tr>
<tr>
<td>Zinc</td>
<td>23.5</td>
</tr>
<tr>
<td>Carbon</td>
<td>Approx. 2</td>
</tr>
</tbody>
</table>

2. Corrosion of buried pipe and other metal structures may be caused by (1) electrically connected dissimilar metals in the earth; or (2) galvanic action of a single metal due to dissimilar soils, variation in moisture content of soil, non-uniformity of the metal caused by mill scale, surface scarring, welding or threading; and (3) temperature differentials.

3. Control of Corrosion

Corrosion can be eliminated or greatly reduced by:

a. Avoid installation of dissimilar metals in the earth or damp locations which are electrically connected. Galvanized conduit connected to copper ground wires is a frequent abuse of this principle.

b. Electrical Isolation

A considerable reduction in corrosion may be accomplished by the strategic isolation of pipe lines or other structures by means of electrical insulation. Insulating couplings, joints, bushings, etc., may be used on pipe of dissimilar metals, or tap lines may be insulated from mains, old lines from new lines, and similar applications. Caution should
be exercised in using insulated joints where high conductivity deposits may accumulate around the insulation either inside or outside of the pipe. Where pipe lines are used for grounding electric systems, the mains must not be discontinuous electrically.

c. Use of Coatings

Metal coatings frequently used on iron and steel are cadmium, zinc, nickel, aluminum, chromium, tin and lead. Cadmium and zinc are less noble than steel and therefore are used for the galvanic protection of iron and steel. These two coatings may also ordinarily be used in contact with aluminum without danger of corrosion.

The major protection derived from paint coatings stems from their ability to act as a mechanical barrier to prevent corrosion from reaching the underlying metal surface. Therefore, they must be impermeable and must adhere intimately to the surface being protected. The coatings must be durable, must not deteriorate chemically, must not react in a corrosive atmosphere, and must not suffer from temperature, radiation, or oxidation exposure. They must not become brittle with age, must have inherent resistance to abrasion and corrosion, and must have a high degree of cohesion.

Plastic tapes with pressure-sensitive adhesive are useful as a coating on short lengths of pipe, at pipe joints, or over other underground metal. Manufacturer's directions as to cleaning, priming and wrapping should be followed. Polyvinyl chloride tape shall not be applied over stainless steels but polyethylene may be used.

Electrically insulating pipe coatings are of great value in reducing the cathodic protection current required. However, poor coatings may be detrimental and inferior to bare pipe in corrosive soils where cathodic protection is not applied because current can leave the pipe through pin holes in the coating. In this case the corrosion is localized and may penetrate the pipe wall in a relatively short time.

C. CATHODIC PROTECTION

1. General

   a. Cathodic protection is the application of direct current, supplied by an external source, to oppose the flow of current from a
metal surface to an electrolyte. A structure is completely protected when all current discharge from the metallic surface to be protected is halted. The commonly accepted criterion of protection for steel is a potential of -0.8 to -0.85 volts, measured to a copper sulfate reference electrode (half-cell) located as near as possible to the steel surface being protected. A voltmeter with an internal resistance of not less than 50,000 ohms per volt is necessary for half-cell measurements.

b. The current requirements for cathodic protection of steel vary over wide limits depending upon the soil aeration and resistivity, the condition of the metal surface, and the type and condition of coatings if any. In some soils bare steel may require less than one millampere per square foot although 20 ma or more may be required in fresh water. Pitted surfaces require more current than smooth surfaces.

2. Galvanic or Sacrificial Anodes

a. The current for cathodic protection may be generated by battery action between the structure and a galvanic anode made from a metal having a more negative solution potential than the metal to be protected. In this case no external current source is required. Magnesium and zinc are widely used for this purpose. In practical installations magnesium has a driving potential of about 1.0 volt to steel and an actual energy capacity of about 500 ampere hours per pound of metal. Zinc develops only about 0.2 volt to steel with a capacity of 335 ampere hours per pound. Due to the low driving potential, galvanic anodes are not recommended for use in high resistance soils (over 1500 ohm-cm for zinc and 5000 for magnesium) unless the steel to be protected is well coated.

3. Externally Applied Cathodic Current

a. Rectifiers are generally used for the source of cathodic protection current for large current requirements or where the water or soil resistivity is high. The driving voltage can be many times that which is available from galvanic anodes.
b. Anodes for external source systems are subject to the same loss of metal as galvanic electrodes. For this reason anodes are usually made of large volumes of scrap metal such as steel, cast iron, or inert materials like platinum and graphite. High-silicon cast iron anodes exhibit inert properties and are very successfully used. Manufacturers literature on graphite and high-silicon iron (Duriron) anodes should be consulted for data on spacing, carbonaceous and mineral backfill materials, maximum current ratings, etc.

D. CATHODIC PROTECTION FOR UNDERGROUND STAINLESS STEEL PIPING AT HANFORD

1. General

a. It is required that all directly buried stainless steel pipe and tanks, either bare or coated, shall be cathodically protected in accordance with Section E-11 of the Hanford Electrical Standards and the following. The cathodic protection system shall be installed and operating concurrent with placement of stainless steel pipe in the earth. Electric arc welding methods shall not be used on pipe in contact with the earth until after the cathodic protection current has been applied. The welding machine and welding cables shall be completely insulated from the earth. Ground connections to the pipe shall be made as close as possible to each weld location and in a manner to assure the absence of arcing. Grounding methods shall prevent stray currents between the pipe and earth.

b. Adjustment of the protective system shall be performed by the installer according to information furnished by the Commission.

c. Carbon steel pipe may be joined to cathodically protected stainless steel pipe by approved welding procedures provided the entire joint is in contact with the earth after welding.

d. Bolted-flange, electrically isolated joints shall not be used in pipelines where thermal cycling may occur unless the joint is in a location readily accessible for visual inspection and repair.

e. Cathodic protection is not required for stainless steel pipelines and tanks that are enclosed in encasements which completely isolate the stainless steel from the encasement material and the earth. Encasements shall be sloped to catch basins or tanks. All sand, gravel, weeds, and other debris shall be removed from the encasements before final closure.

f. Stainless steel in the average plant area soil is considered sufficiently protected at a potential of -0.7 as measured with a copper-copper sulfate half-cell located at the surface of the earth and at a distance approximately 10 feet from the pipeline. More corrosive conditions may require a potential equal to that required for carbon steel--up to -0.85 volt.

2. Anodes and Conductors

a. Anodes shall be silicon-iron or
graphite constructed and installed according to Hanford Standard Standard E-11-5. They shall be located not more than 150 feet from the pipeline and shall be spaced approximately 300 feet apart on each side of the pipeline, staggered on opposite sides as shown on Standard E-11-1. In congested areas closer spacing may be necessary to adequately cover all parts of the installation.

b. Cathodic protection cable for anode and protected structure connections shall be 600 volt, stranded, copper conductor with polyethylene insulation and polyvinyl chloride jacket as specified on Hanford Standard E-11-1. Red color shall be used for positive circuits and black for the negative side. The minimum size shall be No. 4 Awg.

Conductors shall be buried not less than 18 inches below grade and laid in a sand cushion. The anode (positive) conductor shall be covered by 1 x 8” pentachlorophenol-treated wood boards. Splices shall be made in above-ground junction boxes, or may be made underground using an approved cast resin splicing system. See Standard E-11-1. Any current leakage to ground from the anode (red) wiring will quickly destroy the conductor. Junction box stations are shown or Standards E-11-10 and 11.

c. Conductors shall be attached to stainless pipe as follows: a 12-inch long (minimum) stringer of stainless steel strip is to be welded to the pipe. The conductor shall be brazed or welded by means of the 'Cdweld' process to the stringer and the joint carefully insulated with insulating varnish and wrapped with plastic electrical tape. The foregoing is shown on Standard E-11-15.

3. Power Source

   a. Under no circumstances shall provision be made for the manual or automatic connection of the cathode to anode in the event of a power outage supplying the cathodic protection rectifier. Power supplies shall be equipped with full-wave or bridge-type rectifier units.

   b. Rectifiers shall have a d-c output of at least 24 volts. This may not be adequate in some areas of high resistivity so l in which case a higher voltage unit may be employed. Oil-immersed rectifiers are preferable and should be specified where possible. Rectifiers shall be suitable for outdoor mounting with primary supply for 115/230 volts, single-phase, a-c.

E. OTHER FACTORS AFFECTING CORROSION OF STAINLESS STEEL

1. Because welding methods have a direct bearing on corrosion of metals,
the welding practices and materials for stainless steel pipe shall be in strict accordance with HPS-230-W, Standard Specification for Welded Stainless Steels.

2. Good drainage should be provided in the vicinity of buried pipelines. 'Wet tamping' of the backfill shall be avoided unless cathodic current has previously been applied.

3. Stainless steel pipe shall be handled carefully to avoid scratches and abrasions. It must be protected from intimate contact with other metals to prevent local contamination--handling and bending tools should be covered with a nonmetallic material or faced with smooth stainless steel. Walking on the bare pipe is prohibited.

4. The use of wood for supports in contact with the buried stainless pipe is prohibited. Common clay brick may be used for that purpose.

5. Buried pipelines or other metals not necessarily protected but in the vicinity of cathodic protection systems may collect and conduct ground currents in some part of the line. Severe corrosion may occur where the current leaves such metal. Stray currents can be controlled by electrical isolation (see paragraph B-3-b) or by bonding together of adjacent metal parts. However, in the absence of cathodic protection, stainless steel must not be connected to any unlike metals. No general rules for the solution of such difficulties can be given and each case will require individual study. Field measurements should be made after the installation to verify the effectiveness of the system.

F. REFERENCES

Although the literature on corrosion and cathodic protection is voluminous, the following will be of particular help to the designer in the control of corrosion.


Additional Explanatory Notes

This chart is reproduced from a British publication. Permission for its reproduction has been obtained.

When using the chart, corrosion of the "metal considered" is the point in question, not corrosion of the "contact metal". For example, if steel is the metal considered and copper is the contact metal, the code letter is C indicating marked corrosion of the steel. Where the above conditions are reversed and copper is the metal considered, the code letter is A which means no increased corrosion of the copper due to its contact with steel.

The presence of moisture or other electrolyte is assumed in all cases.

<table>
<thead>
<tr>
<th>Metal Considered</th>
<th>Contact Metal</th>
<th>Code Letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gold, platinum, rhodium, silver</td>
<td>—</td>
<td>B</td>
</tr>
<tr>
<td>2. Monel, Inconel, nickel/molybdenum alloys</td>
<td>C(b)</td>
<td>C</td>
</tr>
<tr>
<td>3. Cupronickels, silver-solder, aluminium-bronzes, tin bronzes, gummets</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>4. Copper, brasses, &quot;nickel silvers&quot;</td>
<td>C(a)</td>
<td>C</td>
</tr>
<tr>
<td>5. Nickel</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>6. Lead, tin and soft solders</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>7. Steel and cast iron (a/l)</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>8. Cadmium</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>9. Zinc</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>10. Magnesium and magnesium alloys (chromated) (b) (a)</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>11. Austenitic 18/8</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>12. Stainless steel</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>13. 18/2 Cr/Ni</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>14. Chromium</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>15. Titanium</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>16. Aluminium and aluminium alloys (b) (a)</td>
<td>D</td>
<td>D</td>
</tr>
</tbody>
</table>

(a) The exposure of iron, steel, magnesium unprotected condition in corrosive environment, the absence of bimetallic contact.

(b) Except when used for affording cathode protection should not normally be used in an uncharged volume of water (as opposed to a film of junction, they should, even when chromated and copper parts such as nuts, bolts, washers, plated or otherwise protected. If, however, insulation may sometimes be unnecessary but specialist.

(c) Where contact between magnesium and aluminium alloys with low or negligible copper, protected by a much higher degree of protection with tin or nickel and cadmium of similar thickness. The aluminium anodized is not practicable.

(d) If in contact with thin (decorative) plating (as used for wear resistance) the symbol (a) can be avoided, a much higher degree of protection copper-rich material with tin or nickel and cadmium of similar thickness. The aluminium anodized is not practicable.

(e) The corrosion of mild steel may not be significant when used for wear resistance the symbol (a) can be avoided, a much higher degree of protection copper-rich material with tin or nickel and cadmium of similar thickness. The aluminium anodized is not practicable.

(f) When magnesium corrodes in sea-water, the aluminium cathode may attack the anodic.
**FREE OF CORROSION AT BIMETALLIC CONTACTS**

From the document "Corrosion and its Prevention at Bimetallic Contacts" by the Admiralty and Ministry of Supply and the Inter-service Metallurgical Research Council, Published by Her Majesty's Stationery Office, London, 1956.

- **Table:**
  | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2 | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A |
| (a) | B | — | A | A | A | A | A | A | A | B or C | B | A | B or C | C | A |
| (b) | F or C | B or C(g) | — | B or C | B or C(p) | A | A | A | A | B or C | B or C | A | B or C | C | A |
| C | B | A | A | — | A | A | A | A | A | B or C | B or C | A | B or C | C | A |
| C | B or C(t) | B or C(q) | B or C(q) | B | — | A or C(r) | A | A or C(t) | A | B or C | B or C | B or C | C | A |
| C | C | C | C | C(k) | C(k) | — | A(k) | A(mid) | A | C | C | C | C | C |
| C | C | C | C | C | C | C | B | C | — | A | A | A | C | C | C |
| D | D | D | D | D | D | D | B or C | B or C | — | C | C | C | C | C | C |
| A | A | A | A | A | A | A | — | A | A | A | A | A | A | A | A |
| 2 | A or C(s) | A or C(s) | A or C(s) | A | A | A | A | — | A | A | (o) | A | |
| C | C | C | C | B or C | A | A | A | A | A | C | C | — | C | — |
| A | A | A | A | A | A | A | A | A | A | — | A | — | A | — |
| D | C | D(e) | D(e) | C(k) | B or C | B or C | B or C | B or C | A | A | A(c)(k) | B or C | B or C | B or C | C |
| NOTES |

- Magnesium alloys and unclad aluminium-copper alloys in an environment should be avoided wherever possible, even in the absence of cathodic protection, magnesium and magnesium alloys are unsuitable unless otherwise protected. When tested against continuous corrosion, magnesium and magnesium alloys may be protected by immersion in more noble metals. Steel, brass, copper, etc., should be galvanised, cadmium or aluminium, without jointing compound (D.T.D. 369A) is employed. It is advised that a Service corrosion resistant finish be used instead of the copper coating material is preferred.

- Copper-rich materials and aluminium alloys cannot be protected against corrosion by first spreading the metal with a coating of magnesium oxide in contact with the copper-rich material. Such materials are not of interest when the aluminium alloys are connected with each other.

- In many cases the "contact metal" may provide an excellent protective coating for the "metal considered", the latter usually being electrochemically protected at gaps in the coating.

- When aluminium is alloyed with appreciable amounts of copper, it becomes more noble and when alloyed with appreciable amounts of zinc it becomes less noble. These remarks apply to bimetallic contacts and not to the inherent corrosion resistance of the individual aluminium alloy. Such effects are mainly of interest when the aluminium alloys are connected with each other.

- In some immersed conditions, the corrosion of copper or brass may be accelerated at ports or defects in tin coatings.

- In some immersed conditions there may be serious acceleration of the corrosion of soldered seams in copper or copper alloys.

- Normally the corrosion of lead-in soldered seams is not significantly increased by their use when soldered to the nickel-base alloys in contact with the nickel-base alloys but under a few immersed conditions the seams may suffer enhanced corrosion.
## SION AT BIMETALLIC CONTACTS


**Metal**
- Contact metal
- "Contact metal"

**Introduction**
- "Contact metal" is a material containing an electrolyte, e.g., salt, acid, combustion products. In ships, acceleration may be expected to occur under less severe conditions. Under more severe conditions, the acceleration may be slight or negligible.
- Without adequate protection measures, serious corrosion may occur.

### Table: Bimetallic Contacts

<table>
<thead>
<tr>
<th>Contact Metal</th>
<th>Nickel</th>
<th>Lead, tin, and soft solders</th>
<th>Cadmium</th>
<th>Zinc</th>
<th>Magnesium and magnesium alloys (chromated)</th>
<th>Stainless Steel</th>
<th>Chromium</th>
<th>Titanium</th>
<th>Alumina and aluminium alloys</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nickel</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Lead, tin, and soft solders</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Cadmium</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Zinc</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Magnesium and magnesium alloys (chromated)</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Chromium</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Titanium</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Alumina and aluminium alloys</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
</tbody>
</table>

### Notes
- When it is not practicable to use other more suitable methods of protection, e.g., spraying with aluminium, zinc may be useful for the protection of steel in contact with aluminium, despite the accelerated attack upon the coating.
- This statement should not necessarily discourage the use of the "contact metal" as a coating for the "metal considered", provided that continuity is good and under abrasive conditions, however, the coating may become discontinuous.
- In most supply waters at temperatures above about 60°C, zinc may accelerate the corrosion of steel.
- In cases the "contact metal" may provide an excellent protective coating for the "metal considered", the latter usually being electrochemically protected at gaps in the coating.
- When aluminium is alloyed with appreciable amounts of copper, it becomes more noble and even alloyed with appreciable amounts of zinc it becomes less noble. These remarks apply to bimetallic contacts and not to the inherent corrosion resistance of the individual aluminium alloy. Such effects are mainly of interest when the aluminium alloys are connected with each other.
- No data available.
- In some immersed conditions, the corrosion of copper or brass may be seriously accelerated at pores or defects in tin coatings.
- In some immersed conditions there may be serious acceleration of the corrosion of soldered seams in copper or brass alloys.
- When exposed to the atmosphere in contact with steel or galvanised steel, lead can be rapidly corroded with formation of PbO at narrow crevices where the access of air is restricted.
- Serious acceleration of corrosion of 18/8 stainless steel in contact with copper or nickel alloys may occur at crevices where the oxygen supply is low.
- Normally the corrosion of lead/tin soldered seams is not significantly increased by their contact with the nickel-base alloys but under a few immersed conditions the seams may suffer enhanced corrosion.

---

**SDC-7.10**
SDC-9.1

STANDARD DESIGN CRITERIA
FOR
NOISE CONTROL

This Section consists
of 1 page.
A. GUIDE FOR NOISE EXPOSURE AT THE HANFORD OPERATION

The Guide for Noise Exposure Evaluation and Control published by the Hanford Environmental Health Foundation, Environmental Health Sciences Department, Richland, Washington, establishes the safe levels of noise exposure and shall be used as the basis for noise control and noise protection at Hanford.

If further explanation of the subject information or other aspects of industrial noise is required, it is suggested that Environmental Health Sciences be contacted.

B. REFERENCES


(2) ANSI Standard Sl.1, Acoustical Terminology

(3) ANSI Standard Sl.2, Method for Physical Measurement of Sound

(4) ANSI Standard Sl.4, Sound Level Meters

(5) ANSI Standard Sl.6, Preferred Frequencies and Band Numbers for Acoustical Measurements

(6) ANSI Standard Sl.11, Specification for Octave, Half-Octave, and Third-Octave Band Filter Sets

(7) ANSI Standard S3.4, Procedure for the Computation of the Loudness of Noise