U.S. DEPARTMENT OF ENERGY
STRATEGIC PETROLEUM RESERVE

Level III
Design Criteria

MS-U-901-003

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Approved by:

[redacted]
Project Manager
Strategic Petroleum Reserve

VERSION HISTORY U.S. DEPARTMENT OF ENERGY STRATEGIC PETROLEUM RESERVE PROJECT PERFORMANCE CRITERIA LEVEL III		
VERSION	DESCRIPTION	EFFECTIVE DATE
4.0	Updated Appendix A and references throughout. Updated Chapter 12 Fire Protection to include the use of escalation on loss limits per DOE Order 420.1C. Updated Chapter 15 Communication to include latest technology. Updated Chapter 8 Pipelines to clarify that pipeline design velocities are applicable to steel pipelines and not HDPE. Incorporated approved ECP EC-2021-000001 for Chapter 9 to allow use of third-party testing service for CO sampling. Incorporated approved ECP EC-2021-000057 for Chapter 4 and 8 to require pumps/motor design to be sized for the worst-case fluid properties.	02/2022
3.0	This document was revised to incorporate all approved outstanding ECPs that have accrued since the previous version and includes additional proposed changes: Previously approved changes include: EC2013001346, Cool Roof Implementation EC2017000041, Helical Pipe for RW and Brine Service EC2017000058, Allow HDPE Pipe for Brine Service EC2017000084, Sections 4, 13, & 14, Add MS-I-910-006, Control System Functional Specification, as the standard for instrumentation and control at the SPR EC2018000002, Revise Section 12, Fire Protection EC2018000007, Drawings Categories EC2017000079, Standardize on Class 900 Wellhead Top Section EC2018000077, Revise Level III Criteria 4.2.4.5 Relief Valves	04/2020

	EC2019000047, Secondary Containment Upgrades Additional changes are proposed to incorporate lessons learned and to update for Best Industry Practices	
2.0	This document was revised to incorporate all approved outstanding ECPs that have accrued since the previous version. Changes incorporated include: VA-M/O-8475, Revise SPR Level III Criteria to incorporate lessons learned WH-M/O-1887, Modify Outdoor Lighting Requirements to Design Level III Criteria VA-M/O-8421, Modify Level III Criteria VA-M/O-8404, Minor Revisions to Design Criteria Level III VA-M/O-8511, Revise Level III – Section 8.4 Pipeline Leak Detection VA-M/O-8509, Revise Design Criteria Level III, Chapter 12 VA-M/O-8546, Revised Design Criteria Level III Requirements for AHJ Approval of Fire Protection Waivers VA-M/O-8540, Revised SPR Level III Criteria for Intrusion Detection Tamper Capability VA-M/O-8560, Modify Level III Criteria for Helipad Design VA-M/O-8559, Modify Level III Criteria for UPS Batteries in CAS	06/2016
1.0	This document was revised to remove several requirements that were duplicated in the Level II Project Performance Criteria as well as non-criteria requirements that were outdated because of regulatory requirement or industry practice changes. Approval authority driven by ECP #VA-M/O-8376	11/2001
B	General Revision	12/1994
A	First Official Revision	3/1987
----	Original Publication	1980

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CHAPTER 1

PREPARATION AND PRESENTATION OF DATA

1.1 PURPOSE

This chapter establishes the Strategic Petroleum Reserve (SPR) Design Criteria for uniform preparation of designs and presentation of data.

1.2 DESIGN - DATA

The SPR 2D Drafting Standards Specification 01500 shall be used for all new and revised 2D design drawings. The SPR 3D Drafting Standards Specification 01510 shall be used for all new and revised 3D design drawings. Where dual coverage of a subject occurs between the 2D/3D Drafting Standards and this document, this criterion shall take precedence.

The SPR SmartPlant® Enterprise Design Standards Specification 01520 describes the approach to implement Hexagon's SmartPlant® Enterprise and execute services for the SPR Program using the SmartPlant® applications. It defines the architecture, organization and use of the SmartPlant® Estate to execute the work.

Design data will be captured and managed in a data-centric CAD environment that will create and manage design data used to publish design documents for work package design deliverables that will be used for construction and will also create the published as-built technical baseline.

1.3 PUBLISHED DESIGN DOCUMENT NUMBERING SCHEME

SPR published design document scheme shall use the following format:
Site Name – Discipline – Document Category – Sequence Number.

1.3.1 SITE NAMES

The site names that must be reflected in the document number shall be as indicated below:

- Bayou Choctaw - BC
- Big Hill - BH
- Bryan Mound - BM
- West Hackberry - WH
- St. James – SJ
- New Orleans – NO
- Multiple Sites – MS
- Sun Pipeline – SP
- Vapor Pressure/Degas – VP

1.3.2 DISCIPLINES

In addition to the site abbreviation, document titles shall be prepared and listed by disciplines as shown below:

• Architectural	“A” Series
• Civil	“C” Series
• Data Systems	“DS” Series
• Electrical	“E” Series
• Fire Protection	“FP” Series
• Instrumentation	“I” Series
• Mechanical	“M” Series
• Operations	“OP” Series
• Process	“P” Series
• (Physical Protection) Security	“PP” Series
• Recovery	“R” Series
• Structural	“S” Series
• Unassigned	“U” Series

1.3.3 DOCUMENT CATEGORIES

The various document title categories used on the SPR are shown below. An asterisk indicates a Technical Baseline category:

MISCELLANEOUS

CATEGORY	TITLE
000	MISCELLANEOUS/STUDIES

MECHANICAL

CATEGORY	TITLE
100	COVER SHT / DRAWING INDEX
*101	PROCESS FLOW DIAGRAMS
*102	MECHANICAL FLOW DIAGRAMS
*103	PIPING & INSTR. DIAGRAMS
*104	UTILITY FLOW DIAGRAMS
*105	PIPING PLANS
*106	AREA PLANS
107	PIPING SECTIONS
109	DEFINITIVE ISOMETRICS
110	SCHEMATICS
111	SPOOL SHEETS
112	FABRICATION DRAWINGS
114	SITE PLOT FLOW SCHEMATIC
120	BUILDING PLUMBING
*122	WELLHEAD DRAWINGS
*123	WELL COMPLETION CONFIG.
125	BUILDING HVAC
126	PIPING MISCELLANEOUS
*130	VALVE LIST
*135	LINE LIST
*140	PSV LIST
150	MECHANICAL STANDARDS
180	PROCESS & MECH. CALC

CIVIL/STRUCTURAL

CATEGORY	TITLE
200	COVER SHT / DRAWING INDEX
*201	PLOT PLANS
*202	SITE WORK: GRADING, ETC
203	ROADWAYS, DRIVEWAYS, ETC
204	PONDS, RESERVOIRS, ETC
205	SANITARY SEWER SYSTEMS
206	GRADE SELECTIONS
*210	FOUNDATION LOCATION PLAN
211	FDNS: PILE & DRILLED PIER
212	FDNS: EQUIP & PIPE SUPPT
215	SECTIONS & DETAILS
216	N/A
220	CONCRETE MISCELLANEOUS
221	PLATFMS, LADDERS, STRS. ETC
222	ANCHOR BOLT SCHEDULE
223	STRUCT. SECTIONS & DETS.
230	STRUCTURAL STEEL
231	CIVIL / STRUCT. MISC.
232	SURVEY DRAWINGS
250	CIVIL / STRUCT. STANDARDS
280	CIVIL & STRUCT. CALC

ELECTRICAL

CATEGORY	TITLE
300	COVER SHT / DRAWING INDEX
*301	AREA CLASSIFICATION PLAN
*302	ONE-LINE DIAGRAMS
*303	SCHEMATIC DIAGRAMS
*304	POWER PLANS & DETAILS
*305	LIGHTING PLANS & DETAILS
306	POWER LINE PLANS & DETS.
*307	SUBSTATION PLANS & DETS.
*308	WIRING DIAGRAMS
309	POWER & CTRL JUNCT BOXES
*310	GROUNDING
*311	CONDUIT & CABLE SCHEDULE
312	MISC. / PANEL SCHEDULES
*313	MCC / SWITCH GEAR ELEVS.
*315	CATHODIC PROTECTION
316	ELECT. SECTIONS & DETAIL
*350	ELECTRICAL STANDARDS
380	ELECTRICAL CALCULATIONS

INSTRUMENTATION

CATEGORY	TITLE
400	COVER SHT / DRAWING INDEX
*401	BLOCK DIAGRAMS
*402	LOOP DIAGRAMS
*403	INSTRUMENT PLANS & DETS.
*404	INSTRUMENT WIRING DIAGS.
406	INSTRUMENT GROUNDING
407	CTRL PANEL ELEVS & DETS
408	INSTRUMENTATION MISC.
*409	INSTRUMENT INDEX
410	SECTIONS & DETAILS
411	INSTR BASIS OF DESIGN
412	CONTROL SYSTEM ARCH.
413	INSTR GENERAL SPECIFIC
414	INSTR DATASHEETS
415	ALARM SUMMARY
416	I/O LIST
417	CONTROL NARRATIVE
418	CAUSE & EFFECT MATRIX
419	INSTR INSTALL. DET PROC
420	INSTR INST. DET HYD/PNEU
421	INSTR INSTALL. DET ELEC
422	INSTR CABLE ROUTING
423	INSTR CABLE SCHEDULE
424	INSTR JUNC BOX LOC PLAN
425	LOOP TEMPLATE SCHEM DIAG
426	PANEL SCHEMATIC DIAGRAM
427	INSTR BULK MATERIAL LIST
428	MATERIAL REQUISITION
429	TECHNICAL BID EVALUATION
430	INSTR PKGD. EQUIP. REQ'S
*450	INSTRUMENT STANDARDS
480	INSTRUMENT CALCULATIONS

MAPPING / PIPELINE

CATEGORY	TITLE
500	COVER SHT / DRAWING INDEX
*501	PIPELINE ALIGNMENT SHEET
502	PROPERTY PLATS
503	HIGHWAY PERMITS
504	RAILROAD PERMITS
505	CORPS OF ENGINEER DWGS
506	MISCELLANEOUS PERMITS
507	STANDARD DRAWINGS
508	CONSTR DWGS, RIVERS ETC
*509	PIPELINE DRAWINGS
510	MAPPING MISCELLANEOUS
511	GRAPHICS
550	MAPPING STANDARDS
580	PIPELINE CALCULATIONS

ARCHITECTURAL

CATEGORY	TITLE
700	COVER SHT / DRAWING INDEX
710	CONSTRUCTION SEQUENCE
*720	ELEVATIONS & FLOOR PLANS
*721	CONTROL BUILDING
722	WAREHOUSE
723	PUMP / COMPRESSOR BUILDING
724	ARCHITECTURAL MISC.
725	ARCH. SECTIONS & DETAILS
740	FINISHING
750	ARCHITECTURAL STANDARDS

INFORMATION DATA & TELECOMMUNICATIONS

CATEGORY	TITLE
801	PHYSICAL DIAGRAMS
802	LOGICAL / BLOCK DIAGRAMS
810	SYST / DEVICE CONF SETTING
820	CYBER SECURITY
850	INFO DATA / TELE STANDARDS
870	EQUIPMENT SPECIFICATIONS
880	SYSTEM / APPLICATION SPECS

DOCUMENTATION

CATEGORY	TITLE
901	TECH / PERFORMANCE / DES.
910	DESIGN / DESCRIPTION BASIS
911	PROCESS SET POINT DOCS
912	EQUIPMENT LIST
913	MOTOR OPERATED VALVE LIST
915	ELECTRICAL SAFETY
916	CRITICAL ITEMS LIST
920	I/O DOCUMENT
930	OPS. & MAINTENANCE DOCS
940	ENGINEERING DATA SHEETS
950	STANDARD SPECIFICATIONS
970	TASK SPECIFICATIONS
980	MISC. CALCULATIONS
990	CONFIG. MGT. RPRTS / IBOM

1.3.4 SIGNATURES AND INITIALS

Each drawing issued AFC shall be initialed by the design engineer, the drafting designer, and the drafting checker. In addition, construction drawings and changes shall be sealed by a Professional Engineer (PE) registered in the state concerned, and the PE's signature and date of sealing shall be affixed to the drawing and change. For task packages prepared by the DOE's A-E, the drawings shall be signed within a "Released for Construction" stamp by the Assistant Project Manager (APM), Systems and Projects for DOE or his/her designee.

1.3.5 DATA-CENTRIC DESIGN CAPABILITIES

Documents prepared in a data-centric CAD environment shall be the SPR preferred method. Computer-generated documents shall be utilized for all new design packages generated by the A-E. Use of conventionally drawn sketches, clouding or marking up existing drawings is permitted for minor modifications during maintenance, for construction field changes, and minor design packages.

1.4 NEW DESIGNS

1.4.1 USE OF BASELINE DRAWINGS FOR NEW DESIGN WORK

New 2D drawings shall be created only for those document types not developed from the SmartPlant database and only when necessary to present new systems, facilities, and equipment, as approved by the Department of Energy (DOE). For these document types, design changes should be made against the existing drawings, rather than creating additional new drawings.

1.4.2 REVISIONS TO APPROVED FOR CONSTRUCTION PACKAGES

All revisions to Approved for Construction (AFC) packages shall follow the M&O contractor's Configuration Management Plan and Procedures.

1.5 CHECKING AND COORDINATION

Preliminary issues of drawings and specifications for design review will be reviewed for concept and conformance to the established criteria. Detail design releases will be reviewed for constructability, operability, and maintainability. Design reviews will be conducted in accordance with approved procedures.

1.6 AS-BUILT DRAWINGS

Each contractor performing construction and modifications shall maintain marked-up drawings depicting as-built conditions. These drawings shall be maintained in a current condition and shall be kept available for review by DOE personnel. The M&O contractor has responsibility to maintain a system that tracks and provides status of the technical baseline drawings and "as-builts," the drawings based on properly executed red-lines/Change Notices (CNs) that reflect completed work.

1.7 DESIGN ANALYSIS

Capital project designs normally begin with a conceptual design document, such as a Conceptual Design Report (CDR) for major projects, or a Description of Work (DOW) for smaller projects. Small maintenance construction type projects may have the concept defined with enabling Enterprise Change Proposal (ECP), as required. CDRs and DOWs provide the design basis for the detail design effort and shall be revised during the detail design phase if there are changes to the concept. At the time of release of the design package for procurement, the CDR/DOW shall reflect the final design.

The AFC task package establishes the baseline for the procurement and construction phases of the task. During equipment acquisition and construction, required vendor and/or contractor documentation, as called for in the technical specifications and drawings, shall be received and entered in the SPR technical data management system after being approved.

The as-built task package documents comprise the final element of the design analysis documentation for a task.

1.8 COST ESTIMATES

1.8.1 PURPOSE

Cost estimating is the process of projecting costs to implement specific defined design packages. The primary steps in preparing a cost estimating are:

(a) Defining and planning the estimating task.

(b) Selecting the estimating structure for preparing cost data.

(c) Collecting, evaluating, and applying the necessary cost and cost-related data.

(d) Applying the proper estimating methods.

(e) Documenting the estimate in enough detail so that it can be reviewed, evaluated, and used in the decision-making process.

1.8.2 TYPES OF ESTIMATE

Cost estimating, cost accounting, and measurement of actual performance must be made on the same basis for all project phases to ensure the compatibility, reliability, and credibility of the estimates. The different types of estimates noted below are required at different stages during the planning, design, and construction phases of the project.

Caution: Estimates are sensitive project information shall be held in strict confidence, and distribution shall be on a need-to-know basis until after award of the contract.

Note: Contingency shall be reduced at each estimate phase based on definitization of undefined scope details.

(a) Conceptual Estimate (Rough Order of Magnitude (ROM), ECP, or DOW): An estimate based on the conceptual engineering approach, the design parameters, applicable codes, specifications, and standards although not fully detailed are used to generate the estimate with a contingency included to cover specific details of the scope which have not been detailed. In addition, quality assurance, layout, construction methods, operations interfaces, and safety requirements are considered.

(b) Title I Estimate (30 Percent): The basis for this cost estimate must include all the items mentioned in the conceptual estimate, plus all the refinements developed during the course of producing the Title I Engineering Package. This includes all drawings, outline specifications, data sheets, bills of material, schedule refinements, definitions of scope, methods of performance, changes in codes, standards, and specifications developed to that point of design and contains a contingency for details which have not yet been fully detailed.

(c) Title II Estimate (e.g., 75, 90 or 100 Percent): An estimate that must include as a basis all the approved engineering data, methods of performance, project definition and parameters, pre-project schedule, and exact detailed requirements. The statement of basis must include a complete list of all engineering data used: (such as drawing data sheets, specifications, bills of materials, job instructions, and proposed schedules).

(d) Approved for Construction (AFC) Design Estimate: An estimate that must include as a basis all the approved engineering data, methods of performance, final project definition and parameters, pre-project schedule, and final exact detailed requirements. The statement of basis must include a complete list of all engineering data used (such as drawing data sheets, specifications, bills of materials, job instructions, and proposed schedules).

(e) Government Estimate: An estimate that is prepared according to the measurable and definable elements of costs and that is consistent with the level that a responding contractor would be required to estimate, such as task, subtask, line item, and work breakdown structure. The estimate must be sufficiently documented to show clearly, the rationale used in developing the quantitative elements as well as the rates. The Government Estimate usually is used as a tool in evaluating the reasonableness of the proposals for a particular procurement action. This estimate generally is done to support negotiations, competitive bid proposals, or offers at the individual contract level rather than at the total project level. All contract terms, operations requirements, and indirect influences shall be included in this estimate. There should be no contingency for undefined scope in this estimate.

1.8.3 ESTIMATE AGREEMENT

Disciplines of the estimates such as site work, exterior utilities, architectural, structural, mechanical, communications, and electrical shall be arranged in the estimate in logical order. Each building or bid shall be estimated by discipline, systems and components, and identified by specification code of accounts. Each system shall be subtotaled within each discipline. Each estimate shall be identified with the following:

(a) Date of the estimate
(b) Sheet number with total sheets
(c) Project title
(d) Project location

(e) Preparing Company's name
(f) Drawing reference(s) made for the scope of work
(g) Estimator's name and space for signature
(h) Initials of the checker
(i) Title of discipline for scope of work

1.8.4 RESPONSIBILITIES

Estimate. The estimate shall be prepared by qualified estimators performing quantity surveys depending on the level of design and shall reflect procurement strategy as required. The estimate shall contain a detailed labor and material breakdown. The amounts of quantitative detailed breakdown, labor standards, material, and contingency shall be identified by estimate sponsor. Each estimate will reflect the items identified as required based on the design level of the estimate.

(a) Item Identification: Item shall be identified with sufficient description to obtain a price quotation from a supplier, example are as follows:

(1) Use "Grating. 1-1/2 inches x 3/16 inch, S.S., w/serrations."

(2) Use "Pump, P-105, 60 gallons per minute, 30-foot head., vertical centrifugal, cast iron head, stainless steel impeller."

(3) Use "Panel, RP-13, NEMA I, 240/120 Volt, 3 Phase 150A.M.L.O., w/16-1P-20A.C.B., w/3-3P-70A.C.B., 5-1P-Spaces."

(b) Labor Cost: The labor "per unit" cost shall include all accumulated costs for a specified crew to install an end-item of construction with a wage determination from Department of Labor defined as the requirement from the Davis Bacon Wage Determination Act. Quantity calculations, developed prices, and other special pricing information used in preparation of this estimate shall be maintained in the estimating file request.

(c) Material Cost: The material "per unit" cost shall be current and include the transportation delivered to the job site. Material taxes, if applicable, shall be applied to the summation of material discipline. Quantity calculations, material quotations, developed prices, and other special pricing information used in preparation of this estimate shall be submitted under separate cover upon request.

(d) Contingency: Contingency is defined as the sum of funds included within an estimate to cover materials, labor, conditions, and risk situations which are an intrinsic part of the presently intended scope of work but are not specifically allowed for elsewhere in the estimate, due to uncertainty either as to their existence, nature, likelihood of occurrence, or magnitude of effect. Such times and situations are likely to occur in the course of every project, but in uncertain combinations and magnitudes. Guidance on contingency is issued by DOE Procedure for Development and Management of Contingencies and Project Management Reserve on Engineering and Construction Projects.

(e) Escalation: Escalation is the projected cost increase associated with dollar inflation for work planned for execution in future years. The appropriate percent increase shall be provided by DOE Finance for the appropriate year the estimate is issued and shall be applied as compound interest within the Total Estimated Cost.

1.8.5 ESTIMATE SUBMITTAL

The submittal shall include the estimate and a bar chart showing the contractors estimated total number of months of construction for the project with a breakdown for site work, major items, and buildings. The transmittal will include other facts considered important by the contractor/ estimator, which may affect the cost of the proposed project or define differentials from the preceding design stage estimate.

1.9 SPECIFICATIONS

SPR Standard Specifications shall be used for design wherever possible. New specifications shall only be prepared with the approval of DOE. As a general policy, the use of trade names, proprietary items, and the drafting of a specification by adopting a manufacturer’s description of a particular commercial article shall be avoided. Sections or project specifications prepared for items of work shall be prepared in a manner to supplement the project drawings only to the extent necessary. Specifications shall not duplicate notes or details of items shown except as may be required for clarity. Organization and numbering of sections shall conform to the publication titled "The CSI Master Format for Construction Specifications." Specification language shall conform to the CSI Construction Specifications Writing: Principles and Procedures.

1.10 GOVERNMENT-FURNISHED PROPERTY

When government-furnished, contractor-installed materials or equipment (GFP) are involved, such government-furnished property shall be shown on a separate list which will be submitted with the final design package. Data for the government property shall comply with the requirements of this chapter.

1.10.1 CONTRACTOR FURNISHED EQUIPMENT

When the construction subcontractor is required to supply engineered equipment such as valves, actuators, pumps, motors, instruments, etc., which are assigned an equipment location number (ELN). The equipment to be provided will be shown on a separate list, which will be included in the design package.

1.11 DRAWINGS, SPECIFICATIONS, AND OPERATIONAL SOFTWARE CONFIGURATION MANAGEMENT

All contractors shall implement a proactive system for incrementally documenting and controlling approved engineering changes into the technical baseline documentation per SPRPMO O 410, SPR Configuration Management Program. The intent of the CM system is to effectively implement SPRPMO Order 420.1E, Conduct of Operations (COPS) Requirements.

The M&O contractor shall manage the technical baseline documentation. Drawing numbers, specifications numbers, and change notice numbers shall be issued and controlled by the M&O contractor. All SPR contractors shall interface and comply with the M&O contractor's change notice system procedures.

CHAPTER 2

SITE DEVELOPMENT

2.1 PURPOSE

This chapter establishes design criteria for site preparation and development of solution mined caverns for the storage of crude oil.

2.2 DESIGN REQUIREMENTS - SITE INVESTIGATION

Prior to site preparation, a site characterization study shall be performed that includes surface development history, subsurface geology, and all available geotechnical studies of the site.

A geological site characterization report will be prepared for the site using available data. This report will characterize the surface and near surface geology and hydrology with regard to its impact on surface and subsurface facilities, given to location and condition of mineral production and abandoned underground caverns where subsidence would affect surface and subsurface facilities. A salt dome study will be included that will map the dome boundaries through the zone of interest and assess the interior makeup of the salt dome by analysis of drill records, salt cores, and well log data. Caprock studies will be included to quantify the effects of sulfur mining and mud-filling and to assist in predicting drilling problems, future subsidence, or possible cavern collapse or casing leakage. The potential effects of natural hazards on the local geology will be assessed, and recommendations will be made for future characterization studies, if needed, to develop data critical to adequately characterize the site.

2.3 DESIGN REQUIREMENTS - SITE PREPARATION

2.3.1 SITE SELECTION

Storage site selection shall be based on the following considerations:

- Geologic, geographic, and economic feasibility based on surface and subsurface parameters.
- Solution-mined sites with ready access to raw water and brine disposal.

- Accessible to heavy equipment.
- Geotechnical suitability of the salt formation.
- Overall size of salt formations available for storage.
- Chemical analysis of pertinent formations.
- Estimated volume of insolubles.
- Total quantity of oil to be stored.
- Urgency to start storing oil.
- Proximity to construction labor and adequate electric power.
- Minimal environmental impact.
- Expansion capability.
- Economics of access to commercial terminals.
- Pipeline rates and cost to commercial terminal.
- Pipeline access is feasible to existing crude oil distribution systems, and to a major dock facility capable of handling vessels of 35,000 dead weight tons or greater.
- Location of crude oil demand during an energy emergency.
- Commercial availability of potable water.

2.3.2 SURFACE CONSIDERATIONS

All SPR sites, including that portion of the geologic formation in which storage cavities are developed, shall be Government-owned fee simple, although leasing can be considered with Deputy Assistant Secretary (DAS) approval. The boundary of any storage cavity, at its maximum designed size, shall maintain any legally mandated or engineering justified distance from adjoining property to assure adequate separation, integrity, safety, and security of the SPR site and adjacent property.

SPR sites selected for solution-mined storage shall have sufficient surface area directly above the underground storage area to encompass all solution mining and oil injection/withdrawal activities.

2.3.3 FLOOD AND WIND

2.3.3.1 Flood

Site design shall provide for continuous operation with design high water level elevation meeting or exceeding the 100-year flood data for the area.

The design flood load shall be selected from the flood criteria in Chapter 6.

2.3.3.2 Winds

Building classification for wind loads, per American Society of Civil Engineers (ASCE) for all SPR facilities or structures shall be selected based on usage and personnel occupancy, Table 2-1.

The design wind load shall be selected from the wind criteria in Chapter 6.

TABLE 2-1

BUILDING CLASSIFICATION FOR WIND LOADS

Facility or Structure Usage and Personnel Occupancy Description	Wind Category Classification ASCE 7, Table 1.5-1
- Non-drawdown essential facilities - Non-mission dependent, which pose no threat to personnel or other drawdown essential facilities	I
- Non-drawdown essential facilities - Non-mission dependent, which could house personnel during a storm	III
- Drawdown essential facilities - Mission Dependent	IV

2.3.4 EXISTING FACILITIES DISPOSITION

2.3.4.1 Relocation

When facilities are relocated as a unit, components shall be tagged as necessary for reassembly. Component units shall be braced, shored, and protected from precipitation, blowing dust or sand as necessary to prevent damage during relocation.

2.3.4.2 Demolitions

When facilities are to be demolished, appropriate operations such as noise control, dust control, debris control and removal, dismantling and salvage shall be performed. Adherence to specific regulatory requirements (e.g., asbestos, lead, silica) may apply. Open excavations resulting from demolitions shall be roped off until filled, as soon as possible, with suitable material to prevent a safety hazard.

2.3.4.3 Abandonments

Facilities, systems, equipment, etc. should be physically removed when permanently taken out of service. Physical removal is the preferred method, however, should it not be practical to physically remove abandoned facilities (i.e., underground pipelines), and modifications shall be made so as not to allow any possibility of accidental use of the abandoned facilities.

2.3.5 ORIENTATION

Distances from surface storage containers to existing structures, public highways, and property lines shall be in accordance with Chapter 12 of this criteria. Adverse adjacent site conditions such as marshes shall be avoided wherever possible. Adjacent residential areas should be buffered by earthwork or landscaping or both, if possible.

2.3.6 GRADING

Overlot grades of two percent for 50 feet and one percent thereafter shall be provided away from buildings to drainage ditch foreslopes. Grades within petroleum spill containment areas shall be two percent minimum away from surface storage containers for 50 feet and one percent thereafter.

2.3.7 STORM DRAINAGE

Runoff quantities shall be computed by the Rational Method as follows:

$$Q = AIR$$

Where Q = Peak Discharge

A = Drainage Area

I = Runoff Factor

R = Rainfall Intensity

Rainfall intensity shall be the worst intensity shown in ASCE/SEI-7 for one-hour rainfall with 10-year frequency or U.S. Weather Service Statistics. Buildings and main roads shall be protected from flooding caused by a one-hour storm with 100-year frequency. Time of concentration shall include overland and channel flow times. The minimum time of concentration, however, shall be five minutes. (Other formulas may be used in lieu of the above after approval by the Department of Energy (DOE) Contracting Officer's Technical Representative (COTR)).

2.3.8 SPILL CONTROL

Provisions shall be made to contain and/or control oil and brine spills. Examples of equipment requiring containment trays are pig traps, meter prover skids, pump pads, fuel tanks, sump/slop oil tanks, oil filled transformers, etc.

2.3.8.1 Above-Ground Tanks

All fixed roof and floating roof tanks shall be diked or have other acceptable secondary containment measures as defined in section s 6.5.1 and 6.5.2.2.

When tanks are grouped within dikes, curbs or ditches shall be provided to protect adjacent tanks from minor leaks. Dikes, curbs, toe walls, and ditches shall conform to

National Fire Protection Association (NFPA) Code 30. Impervious media shall be clay or plastic lining to prevent spilled oil or brine from entering ground water.

2.3.8.2 Wellhead Areas

In accordance with LA Statewide Order 29-M, 321.K, and the Clean Water Act, spill containment at wellheads must be provided. Dikes shall surround the wellheads of caverns to retain liquids released by accidental spillage.

Containment dikes and floors at wellheads or remote basins shall be constructed of impervious fill designed with respect to potential hydraulic loads to be imposed. Containment dikes at wellheads should be limited to six feet high, if possible. Where dikes are higher than six feet, safe egress must be provided. Minimum dike height shall be three feet. Dike crowns shall be a minimum of three feet wide on top and fill material shall be properly compacted.

Containment volume within the wellpad dike shall be large enough to hold the spillage in a "credible worst case" failure scenario, as described in the SPR emergency response procedures. For purposes of design, the credible worst-case spill volume is defined as flow produced through a 2-inch orifice at the maximum operational cavern pressure in the first 4 hours, plus an additional one foot of freeboard to account for fire-fighting water and foam.

Should spill volumes exceed containment volumes, temporary containment afforded in adjacent areas and drainage ditches, controlled with sluice gates or booms, is allowed.

The major containment area shall contain facilities to remove rainwater accumulations through trapped drains, valves, and oil/water separators to a safe location. The discharge valves shall be outside the containment wall and clearly marked.

Drains, culverts, or open spillways between wellhead containment and remote basins shall be capable of handling the spill rate plus expected firefighting water usage.

Channels within cavern dikes shall be paved with asphalt or concrete or covered with smooth stone or compacted clay or similar material to prevent growth of vegetation, which could restrict liquid flow.

The slope of drainways shall be a minimum of two percent for the first 100 feet, one percent thereafter to reduce size. Design shall assume they are flowing full.

Removable barriers shall be provided for vulnerable portions of cavern piping that are subject to vehicle damage.

Electrical equipment in the wellhead containment areas shall be rated for Class I, Division 2 hazardous locations in accordance with Article 500 National Electric Code (NEC), NFPA 70.

2.3.9 ROADS, PARKING AREAS, AND SIDEWALKS

Perimeter roads used primarily for patrol functions shall consist of one traffic lane with shoulders and may be shelled. These roads shall have turn-around areas not more than 500 feet apart. Other roads shall consist of two traffic lanes with shoulders. Traffic lane width shall be 10 feet and shoulder width shall be 6 feet. Traffic lanes shall be surfaced with asphaltic concrete. Horizontal and vertical alignment and other design details shall conform to American Association of State Highway Transportation Officials (AASHTO), "A Policy on Geometric Design of Highways and Streets". Roadway markings and signage should conform to the Manual on Uniform Traffic Control Devices, latest edition.

Parking areas (both on and off-site) shall be asphaltic concrete surfaced with 9-foot by 20-foot parking stalls and access lanes 24 feet wide minimum. Slopes shall not exceed six percent in the direction of parking and four percent perpendicular to the direction of parking. Sidewalks shall be reinforced concrete.

Sidewalks shall be placed on a prepared sub-base and may be as thick and wide as needed to carry out the design concept. Sidewalk longitudinal or transverse slope shall not exceed two percent in areas subject to ice accumulation. Base course and sub-base materials for roads, parking areas, and sidewalks shall be as required by soils reports and test data.

2.3.10 CURBING

Bumper blocks shall be precast reinforced concrete or recycled plastic staked to pavements by driven steel pins. Bumper blocks shall be 6 inches high and approximately 10 inches wide.

2.3.11 LANDSCAPING

Grassing shall provide plants suited to the individual locations. Planting shall be vegetative by sprigging or by broadcast seeding as required for the type of grass. Blown asphalt straw mulch or jute mats shall be provided on turfed slopes steeper than 1 vertical to 4 horizontal. In spill containment areas soil sterilant shall be applied with gravel or rock surfacing to minimize maintenance requirements. Trees and shrubs where required for buffers shall be suited to the locations. Where choices are available, hearty trees and shrubs shall be selected. Trees with fruit and large leaves shall be avoided to reduce maintenance requirements.

2.3.12 SURVEY MONUMENTS

Placement number, location and type of survey monuments and benchmarks shall be in accordance with SPR subsidence monitoring program.

2.3.13 WELL PAD SURFACING

The SPR standard for well pad surfaces is crushed limestone. Minor maintenance and repairs to existing non-limestone surfaces may be repaired in-kind.

2.4 DESIGN REQUIREMENTS - SOLUTION MINED SITES

Storage caverns solution mined in salt domes shall have an initial average crude oil storage capacity of 10 MMB and a useful life of 20 years. They shall be capable of withstanding 5 drawdown cycles in which the drawdown medium will be raw water.

2.4.1 SEISMIC CRITERIA

2.4.1.1 Seismic Risk

Current data indicate storage sites shall be located in areas subjected to minimal seismic risk. Areas falling within the zones classified 5<Ss<10 and 2<S1<6 as defined by Figures 22-1 and 22-2 respectively in the ASCE 7 “Minimum Design Loads for Buildings and Other Structures” are within reasonable safety boundaries with regard to Seismic requirements.

2.4.2 PHYSICAL CHARACTERISTICS

Solution mined caverns shall be uniformly tapered in shape designed to provide for an authorized crude oil storage capacity of 10 MMB and a sump adequate to collect insoluble released during cavern development. To ensure that all caverns are capable of storing authorized capacity for 20 years from completion of development and that an adequate brine cushion is maintained in each cavern, the volume of brine in each cavern will be sufficient to allow for 20 years of cavern creep volume losses plus a volume sufficient to assure that the oil/brine interface is never less than ten feet above the bottom end of the hanging string. The setting depth of the hanging string shall be between 15’ to 25’above the cavern floor. The cavern design criteria are in Table 2.2.

TABLE 2-2

STANDARD SPR 10 MMB CAVERN CRITERIA

Element Description	Initial Formation	After 5 Drawdowns
General Shape	Tapered (Inverted Frustum of a Cone)	Cylindrical (Straight & Vertical Walls)
Roof Peak Location	Below Casing Seat (-0 + 100’)	Same as Initial Same as Initial
Roof Shape	Domed or Conical 15º Minimum 75º Maximum	
Diameter at Top	235’ (-15 + 35’)	270’ Maximum
Diameter at Bottom	160’ (± 30’)	270’ Maximum
Height	2,000’ (± 10%)	2,000’ (± 10%)
Gross Cavern Volume	11.2 MMB (± 0.2 MMB)	21 MMB (± 5%)
Net Storage Volume	10.0 MMB (± 0.2 MMB)	20 MMB ((± 5%)
Brine Cushion	1.0 MMB (± 0.2 MMB)	Refer to Section 2.4.2

Cavern roof depths and resulting cavern sump depths will vary due to variations in depth to the top of salt or other conditions encountered during drilling.

Other geometric criteria are required relating to vertical and horizontal control of cavern location. Horizontal control, such as distances between caverns, distances to edge of dome or to surface property lines, is derived from cavern integrity and area subsidence considerations.

The boundary of any storage cavern at its maximum size shall maintain any legally mandated distance from the adjoining property and in no case shall the wall of the cavern be less than 100 feet from the property boundary. A greater distance to the property boundary is justified where a neighboring cavern field may exist.

To ensure cavern structural integrity the distance(s) between the roof peak and the top of salt shall not be less than 450 feet, or a distance equal to the diameter of the cavern, whichever is greater. The ratio of the web or pillar average thickness (P), between two adjacent caverns, to average final cavern diameter (D) shall not be less than 1.78, (see Table 2-3).

TABLE 2-3
CAVERN HORIZONTAL/VERTICAL CRITERIA

ITEM	MINIMUMS
CAVERN CENTER-TO-CENTER SPACING	750'
CAVERN WEB THICKNESS (P)	480'
WEB THICKNESS TO DOME EDGE	300'
WEB THICKNESS TO PROPERTY LINE	100'
CAVERN ROOF APEX TO TOP OF SALT (S)	450'
RATIO S/D *	1.0
RATIO P/D *	1.78

*BASED ON AVERAGE CONSTRUCTED DIAMETER (D)

2.4.2.1. Shape Criteria

Cavern shapes shall be designed to provide stability and integrity through all five fill/drawdown cycles.

2.4.2.2 Spacing and Proximity Criteria

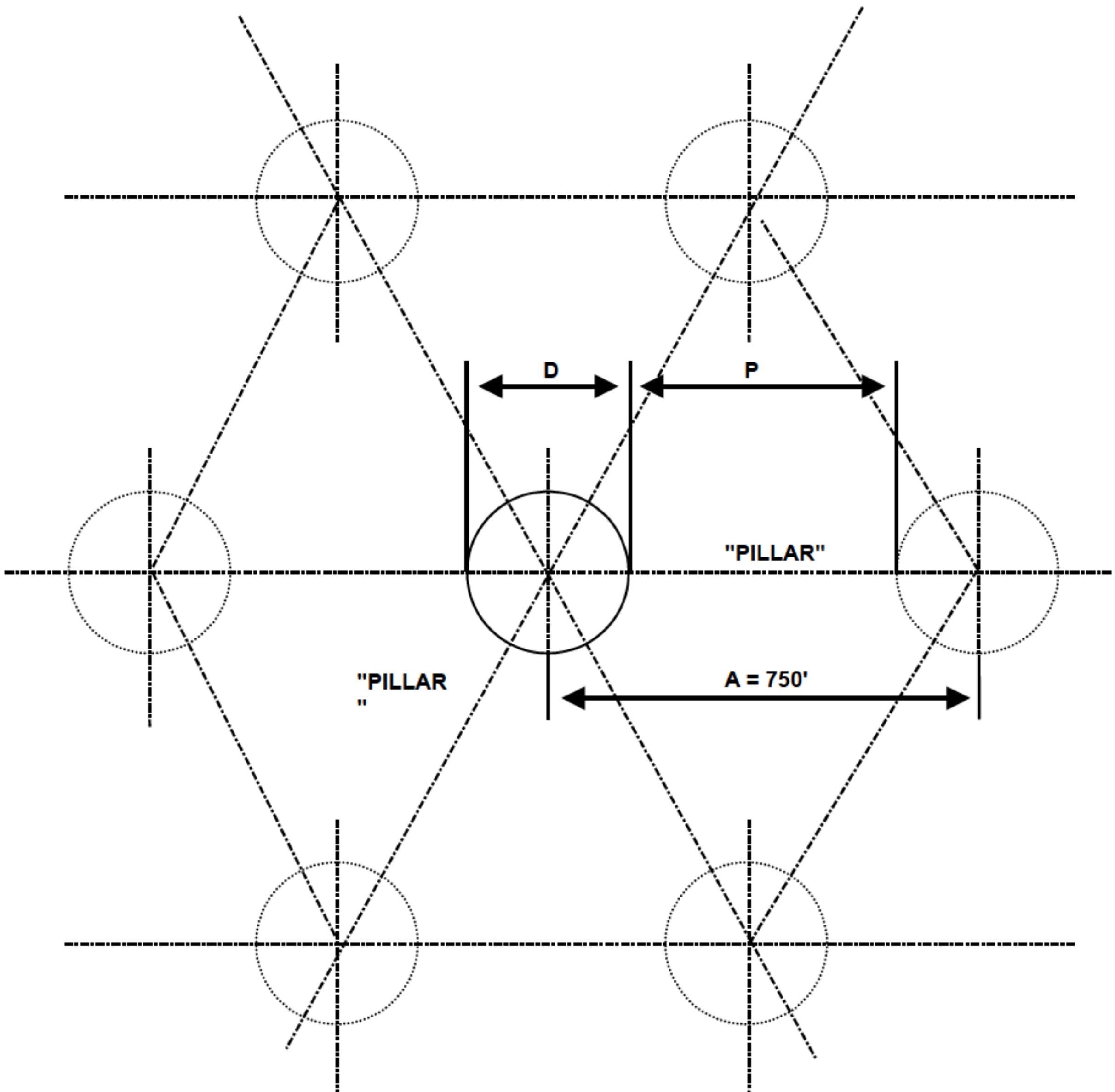
Cavern spacing shall be characterized by the pillar/diameter (P/D) ratio. "Pillar" refers to the minimum thickness of the web of salt remaining between any two adjacent caverns after the last leaching process, or between the cavern and salt dome perimeter. The cavern spacing (A) in a field of caverns is determined by the following equation:

$$A = P + D$$

or, $A/D = P/D + 1$ subject to the constraint that $P/D \geq 1.78$

where: A is cavern spacing; D is cavern diameter after five complete fill and drawdown cycles; P is pillar width after five complete fill and drawdown cycles. Figure 2-1 gives a sketch of these parameters.

FIGURE 2-1 CAVERN SPACING PARAMETERS

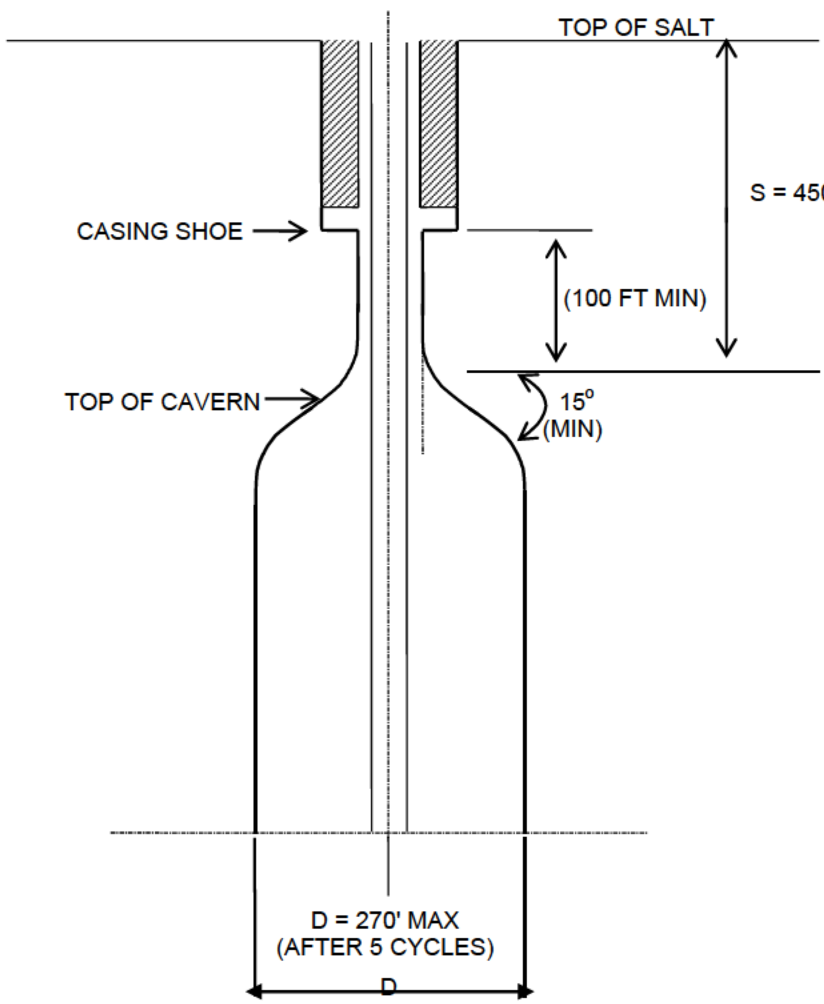


The same approach shall be used to determine the distance between a cavern and the boundary of the salt formation. This distance shall be at least equal to one-half the safe pillar width plus a safety factor added to this width to allow for possible borehole deviation when drilling along with edge of dome uncertainty. This safety factor shall be twice the bottom hole target radius plus the edge of dome uncertainty. The total distance thus determined shall be no less than 300 feet.

2.4.2.3 Depth Criteria

A competent, impervious layer of salt shall be kept above the cavern roof to maintain roof stability, control ground movement (subsidence), and guarantee oil tightness of the cavern. The minimum salt thickness between the cavern apex and the top of the salt formations shall be 450 feet or a distance equal to the maximum roof diameter, whichever is greater. The cavern is assumed to have its initial maximum diameter (D) at the roof. The thickness of the salt above the cavern roof is denoted by S. The minimum distance between the apex of the cavern and the casing shoe is 100-feet, Figure 2-2.

FIGURE 2-2 LOCATION OF CASING SHOE IN RELATION TO TOP OF CAVERN



2.4.2.4 Drilling

Prior to any drilling, the prescribed sequence of operations, including equipment rig up, shall be provided to DOE for approval. DOE shall verify that the permit to drill has been approved by the appropriate state commission.

2.4.2.5 Pressure Criteria

2.4.2.5.1 Maximum Test and Operating Pressures. Test and operating pressures shall be as required in the Level II Criteria. Operating pressure at the shallowest casing shoe seat should never exceed the values shown in Table 2-4.

TABLE 2-4
MAXIMUM TEST AND OPERATING PRESSURES

SITE	LITHOSTATIC OVERBURDEN PRESSURE GRADIENT (LOG) (psi/ft)	MAXIMUM TEST PRESSURE GRADIENT (MTG)* (psi/ft)	MAXIMUM OPERATING PRESSURE GRADIENT (MOG)** (psi/ft)
BAYOU CHOCTAW	0.95	0.85	0.79
BRYAN MOUND	0.91	0.82	0.76
WEST HACKBERRY	0.96	0.86	0.80
BIG HILL	1.0	0.90	0.83

NOTE: FOR ALL OTHER SITES (NEW AND EXISTING) THE LOG, MTG, AND MOG WILL HAVE TO BE DETERMINED. DETERMINATION OF THE LOG SHALL BE BASED ON A STUDY OF THE OVERBURDEN.

* MAXIMUM TEST PRESSURE GRADIENT (MTG). THE MAXIMUM TEST PRESSURE TO BE APPLIED TO THE CASING SEAT WILL BE 90 PERCENT OF THE ESTABLISHED LITHOSTATIC OVERBURDEN PRESSURE FOR THAT SITE NOT TO EXCEED A GRADIENT OF 0.9 psi/ft. FOR CAVERNS WITH MULTIPLE WELLS, THE MAXIMUM TEST PRESSURE LIMITATION WILL BE DETERMINED FROM THE SHALLOWEST PRODUCTION CASING SEAT.

** MAXIMUM OPERATING PRESSURE GRADIENT (MOG). THE MAXIMUM OPERATING PRESSURE GRADIENT WILL BE A FACTOR OF SAFETY OF 1.20 BELOW THE ESTABLISHED LITHOSTATIC OVERBURDEN PRESSURE FOR THAT SITE, NOT TO EXCEED A GRADIENT OF 0.9 psi/ft. FOR CAVERNS WITH MULTIPLE WELLS, THE MAXIMUM OPERATING PRESSURE WILL BE THAT WHICH IS CALCULATED FOR SHALLOWEST PRODUCTION CASING SEAT.

2.4.2.5.2 **<u>Pressure During Workover</u>.** Cavern depressurization to atmospheric wellhead pressure shall take place before any workover is accomplished. An equalization of the pressure on both sides of the wellhead will avoid the risk of crude being ejected in the event of tubing failure during workover. The design to accommodate workovers at atmospheric pressure must allow for "oil bleed" resulting from salt creep. Cavern well designs shall assure that cavern depressurization rates and procedures will not exceed the SPR design safety factors.

2.4.2.5.3 **<u>Cavern Hydraulics</u>**. Process flow and temperature calculations shall be made to study the effects of cavern fill and drawdown and to determine the rates and pressures of oil injection. Limitations to pressures are set forth in Table 2-4.

The following guidelines shall be considered.

- Cavern drawdown rates shall be calculated at the standard 150-psig wellhead oil exit pressure for comparability to other SPR sites. System pressure to the terminals shall determine actual flow rates and pressures.

- Cavern leaching and fill rates shall be calculated using 50-psig wellhead brine exit pressure.

- SPR designed two-well caverns may utilize flow into the cavern through one well and flow out of the cavern through the second well.

- Cavern hydraulics design shall allow 150,000 BPD minimum drawdown at the velocity of 20 fps or less. Flow velocity in excess of 20 fps, but not to exceed 30 fps, may be acceptable to meet unusual situations or flow requirements.

- Flow and pressure calculations shall include the effects of couplings on strings within other tubing.

2.4.2.5.4 **Cavern Fill Limitations**. Cavern fill rate is primarily limited by pressure at the casing seat. Design flow velocities shall not cause pressure at the casing seat to exceed the maximum allowable operating pressure.

2.4.2.6 Wellhead and Casing Criteria

The following criteria shall apply to the SPR standard specifications for wellheads.

2.4.2.6.1 **Wellhead Equipment**. The wellhead is the assembly of casing spools, hangers, fittings and valves, applicable actuators, and miscellaneous items. The wellhead as a system shall be rated at 2,000-psi working pressure and shall be suitable for sour crude oil, water, and brine service. Wellhead casing spool sections and related components must meet API Specification 6A and wellhead valves, flanged fittings and associated equipment must meet API Specification 6D and Specification ASME B16.5 and 16.10, as applicable. The casing spool outlet flanges and the flange which mates with the crown valve shall be Spec API 6A, 3,000 psi, with dimensions to accommodate the flange geometry of a Spec API 6D, 900 series valve which has a maximum rated working pressure of 2,160 psi.

2.4.2.6.2 **Wellhead**. For newly drilled cavern wells, the wellhead components installed on Cavern well BC-102B at Bayou Choctaw is the Phase IV design basis. The typical Phase III wellhead is based upon the original design for Big Hill, modified during the LE I program to add a pressure monitoring outlet on each casing head. This design is referred to as the Phase III SPR Standardized Wellhead, which is comprised of interchangeable components. The sixteen single-well cavern wellhead components at West Hackberry are not compatible with these Phase III wellhead components. Wellhead components installed on cavern wells as part of the LE I program are the Phase III SPR Standardized Wellhead, with the exception of a transition component (adapter or riser spool) to accommodate for the various sizes of Bradenhead flanges and various types of hangers installed on the top joint of the last cemented casing string.

The typical wellhead for a Phase III cavern well in a Leaching Configuration comprises five sections, from bottom to top: A, B, C, D and the top section. The letters refer to the relative location of the equipment on the wellhead. The various wellhead configurations for existing wells are illustrated in Figures 2-3 (Leaching Configuration) and 2-4 (Fill/Storage Brine Configuration).

- Section A, Bradenhead (casing head). Flanged slip-on welded fitting installed on the intermediate surface casing, containing a mandrel-type (or slip-type) hanger to hang and seal the final cemented casing and also having side outlets for valves or gauges.

- Section B, casing spool. Quadruple outlet, flanged spool with a tapered bowl section machined in top portion to land a 10-3/4-inch mandrel-type hanger and to suspend the brine casing string (leaching configuration) and the raw water/brine casing string (designated brine well in fill/storage configuration). Bottom flange machined to seal against the 13-3/8-inch mandrel hanger seal rings. A 6-inch nominal (7-1/16-inch API) side outlet is provided for annular oil flow or annular oil injection into the cavern roof. A 2-inch nominal (2-1/16-inch API) side outlet is provided for pressure monitoring (static oil pressure).

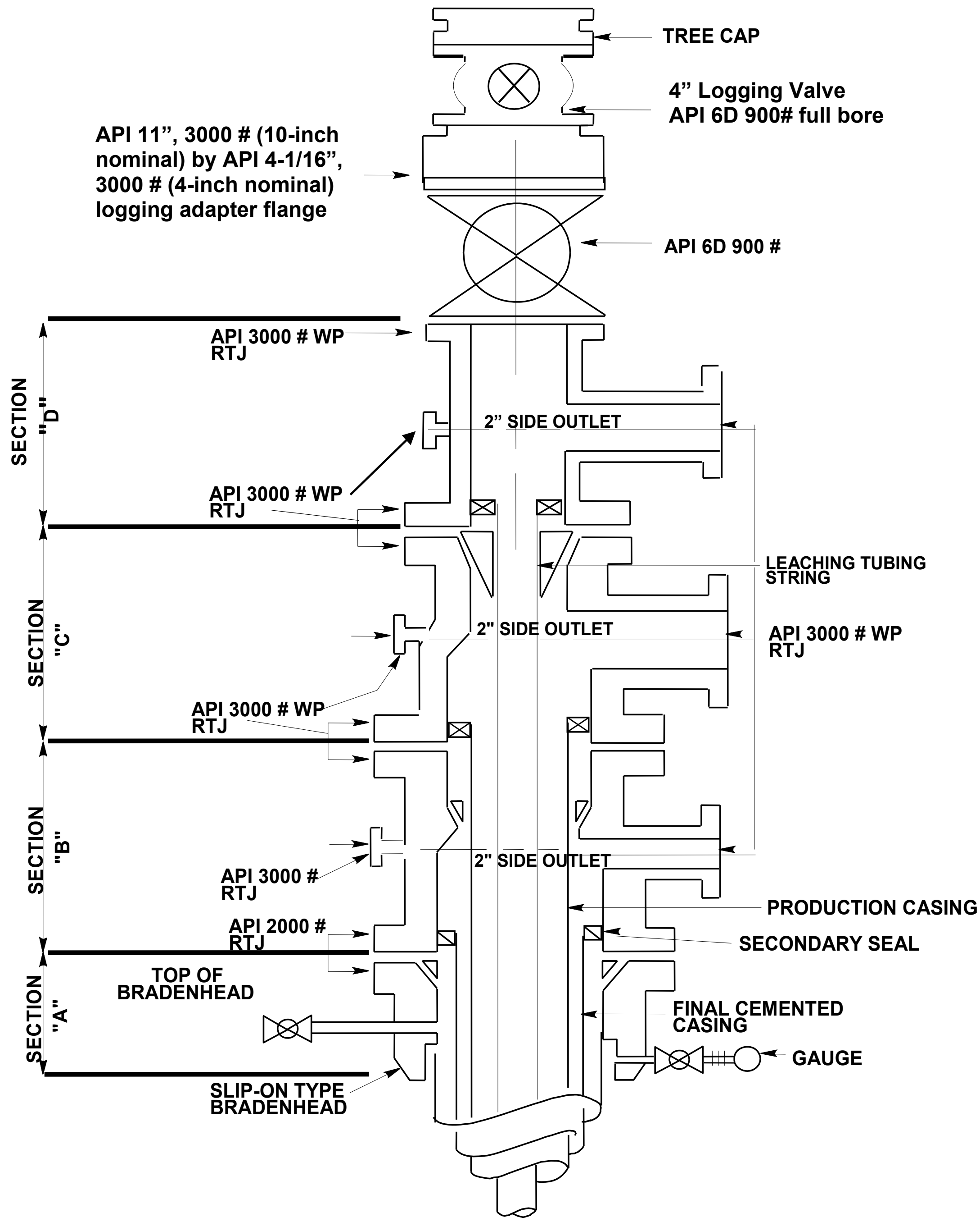
In the Section B position of a designated, existing well in a fill/storage configuration, a double studded adapter (DSA) seal flange with an extended neck and O-ring seals to fit the bottom portion of a Section "C" spool and with the bottom portion machined to seal against the neck of a mandrel hanger (typically a 13-3/8-inch mandrel neck) and O-ring seals will be used.

- Section C, casing spool. Quadruple outlet, flanged spool with a straight bowl section machined in top portion to land a 7-inch mandrel-type hanger and to suspend a raw water casing string (leaching configuration). Bottom flange machined to seal against the neck of a mandrel hanger (typically a 10-3/4-inch mandrel hanger seal rings). A 10-inch nominal (11-inch API) side outlet is provided for brine flow (leaching configuration or designated brine well in fill/storage configuration) or for oil flow (designated oil well in fill/storage configuration). An additional 2-inch nominal (2-1/16-inch API) side outlet is provided for pressure monitoring (flowing raw water or brine pressure for a designated brine well or flowing oil pressure in a fill/storage configuration or flowing brine pressure in a leaching configuration).

- Section D, spool. Quadruple outlet, flanged spool without a bowl section with bottom flange machined to seal against a 7-inch mandrel hanger seal rings. An 8-inch nominal (9-inch API) side outlet is provided for raw water flow (leaching configuration). An additional 2-inch nominal (2-1/16-inch API) side outlet is provided for pressure monitoring (raw water pressure).

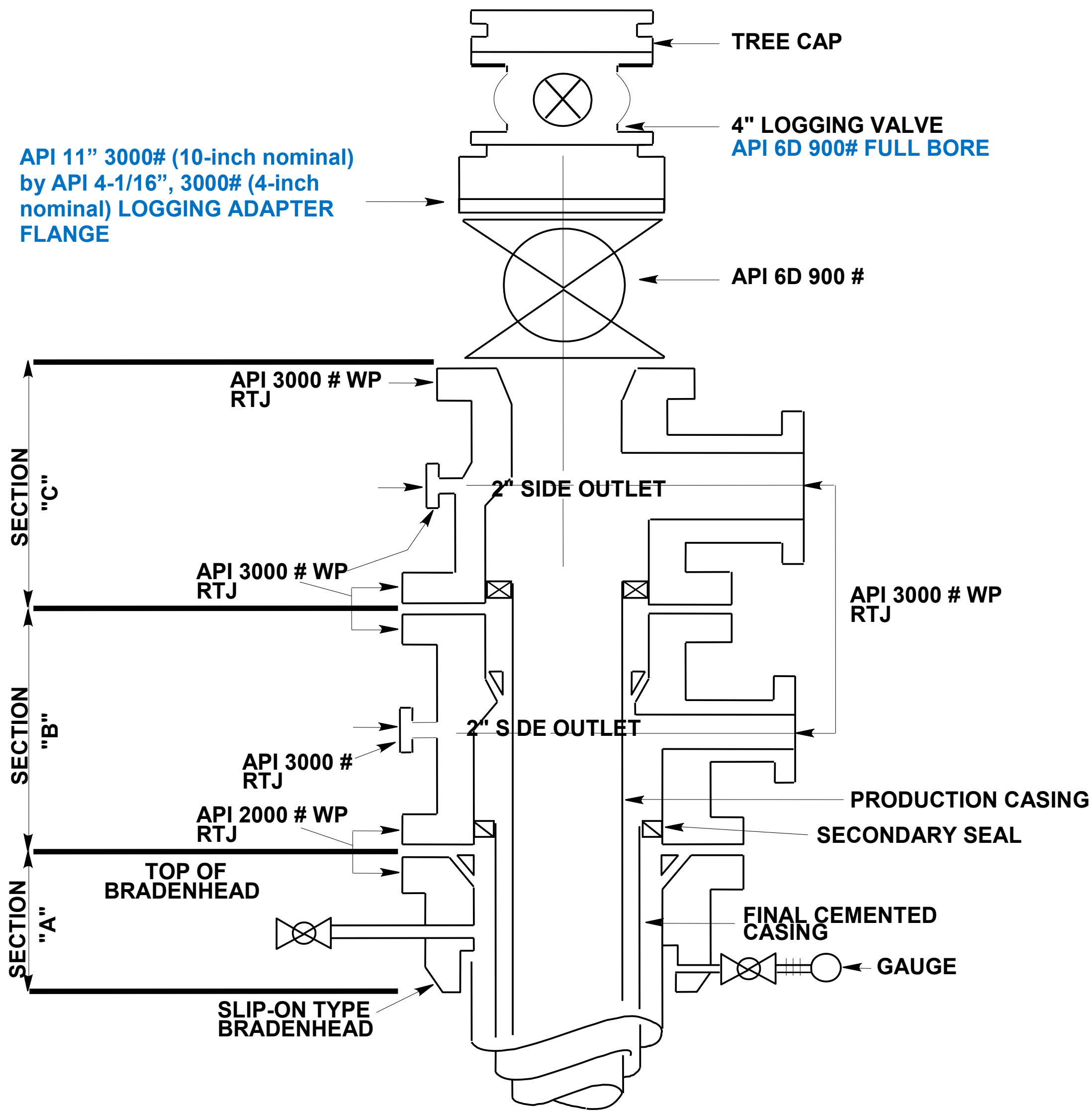
- Top Section. The top section from top to bottom comprises a 4-inch, Class 900 RTJ tree cap; then a 4-inch, API 6D 900# full bore logging valve; then an API 4-1/16”, 3000# (4-inch nominal) by API 11”, 3000# (10-inch nominal) logging adapter flange; and then a 10-inch API 6D, Class 900 RTJ full bore crown valve which is bolted to the top flange of the “C” Section.

For the existing 120 SPR cavern wells, several variations of Figures 2-3 and 2-4. The sixteen single-well cavern wells at West Hackberry, also referred to as Phase II wells, have their own standard wellhead component sizes. The West Hackberry Phase II wells are equipped with a 26-3/4-inch Bradenhead flange whereas the Phase III standard Bradenhead flange size is 21-1/4-inch.



SPR WELLHEAD EQUIPMENT LEACHING CONFIGURATION
FIGURE 2-3

D-424A



SPR WELLHEAD EQUIPMENT
FILL / STORAGE CONFIGURATION
FIGURE 2-4

D-424B

The sixteen Phase II cavern wells at West Hackberry are equipped with interchangeable wellhead components, although not interchangeable with the Phase III standard wellhead components. The West Hackberry Phase II cavern wellhead valves are 12-inch versus 10-inch for the standard wellhead. The casing spools are machined with studded outlets and the top and bottom flanges are API 2000 dimensions including the flange that mate with the crown valve.

At Big Hill, each of the 14 cavern brine wells are equipped with standardized wellhead components illustrated in Figure 2-4. The standard wellhead for each of the 14 slick cavern oil wells at Big Hill will be similar to Figure 2-4. A Phase III wellhead in either a raw water/brine or crude oil/slick configuration is equipped with a standard liner spool when the cased wellbore has undergone a remediation workover project to install a casing-liner.

The cavern wells (located at Bayou Choctaw, Bryan Mound, and West Hackberry) also are equipped with Phase III standardized wellhead components. Each designated slick oil well is equipped with identical components in the Section "C" and top section positions. In addition, each slick well at Bayou Choctaw, Bryan Mound, and West Hackberry is equipped with a transition wellhead component positioned in Section "B" position. The type and size of this transition wellhead component is attributable to variations in Bradenhead flange size, elevation of Bradenhead flange in the well cellar, the type of hanger (slip or mandrel) used to land the last cemented casing string, and the absence of a hanger for the last cemented string. The transition wellhead component is a unique design that features double "P" seals and an extended neck with double O-ring seals to fit the bottom of the Section "C" spool. This design provides two sets of secondary seals to isolate cavern pressure from inside the well and the last cemented annulus. When the Bradenhead flange is above ground level, a transition component (double studded seal flange adapter) approximately 12-inches in height is used. When the Bradenhead flange is in the cellar, the transition component (double studded seal flange riser) ranging from 24-inches to 48-inches in height is used. Other than the height dimensions these two transition components are identical in function and design.

Each brine well at Bayou Choctaw, Bryan Mound, and West Hackberry is equipped with a transition wellhead component positioned between the top of the Bradenhead flange and the bottom of the Section "B" position. The type and size of this transition wellhead component is attributable to variations in Bradenhead flange size, elevation of Bradenhead flange in the well cellar, the type of hanger (slip or mandrel) used to land the last cemented casing string, and the absence of a hanger for the last cemented string. The transition wellhead component is a unique design that features double "P" seals and an extended neck with double O-ring seals to fit the bottom of the Section "B" spool. This design provides two sets of secondary seals to isolate pressure from the oil annulus and the last cemented annulus.

2.4.2.6.3 **Wellhead Valves**. Wellhead valves, including the logging valve, shall be American Petroleum Institute (API) in accordance with DOE SPR

Standard Specification 15347, - “Wellhead Ball Valve”.

2.4.2.6.4 **Wellhead Gaskets**. All gaskets shall be ring-joint type; either R or RX, stainless steel.

2.4.2.6.5 **Hangers**. All hangers used for suspending a casing string shall be mandrel-type or slip-type with provisions for leak testing in-place. Hold-down screws, also referred to as lock down pins shall not be used.

2.4.2.6.6 **General**. In addition to the above, the following criteria shall apply.

- Use material conforming to API standards for sour crude oil valves, casing, tubing, and wellhead components.
- Set the shoe of the final cemented casing at least 350 feet below the top of the salt. Set the intermediate casing a minimum of 100 feet into the salt.
- Cement the casing from the shoe to the surface.
- Wellhead design shall meet API requirements of 2,000-psi service.

2.4.2.7 **Testing and Certification Criteria**

Specific tests are required to evaluate integrity, tightness, and stability of caverns. For details of testing and certification see Chapter 17 of this criterion. In addition, caverns shall be monitored and tested for methane or other gas productions per state regulation.

2.4.2.8 Instrumentation and Control Criteria

The following criteria for instrumentation and control are the minimum consistent with safety. Instrumentation for brine disposal shall meet the Federal and State requirements for environmental monitoring.

2.4.2.8.1 During Leaching. The wellhead system design shall accommodate the following information to be transmitted from the wellhead to the control room:

- Pressure at raw water inlet.
- Pressure at brine outlet.
- Pressure at oil side or the annulus.
- Raw water flow rate into the cavern.
- Position of the main motor-controlled valves.
- Temperature, and flow rate at the oil line outlet.

Raw water valves and brine return valves shall be remotely and manually controlled. The valves shall also be capable of hand operation and have a position indicator. High pressure alarms shall be installed on the oil side. The main raw water and brine pumps shall be remotely and manually controlled with suitable interlocks for remotely controlled startup and shutdown.

2.4.2.8.2 **During Oil Operations**. The following information shall be transmitted to the control room from the wellhead:

- Pressure at the brine side.
- Pressure at the oil side.
- Oil flow rate.
- Position of the main valves.
- Brine flow rate, temperature, and pressure at the outlet.

Brine valves and oil valves shall be remotely and manually controlled. A remote-control valve shall be installed on the brine outlet to bleed off pressure periodically. A high-pressure alarm shall be installed on the oil side and on the first cemented annulus to prevent an excessive pressure buildup on the cemented casing. The main oil pumps shall be remotely and manually controlled with suitable interlocks for remotely controlled startup and shutdown.

2.4.2.8.3 **Metering**. Crude oil flows shall be measured as set forth in Chapter 9 of this criterion. Brine and raw water flow measurement shall be accomplished by metering systems which shall be flow demonstrated accurate to within two percent of total volume transferred.

2.4.2.9 Integrated Cavern Design Criteria

Cavern design is developed with three criteria being the controlling factors: integrity, tightness, and stability. Actual design can be facilitated by utilization of existing computer models for solution mining simulation. The models shall simulate the leaching process and predict the following results:

- The rate of volume creation per day.
- Leach water output salinity.
- Depth to residue bed.
- Cavern shape.
- Oil/brine interface depth.

Input data for the model may include:

- Salt properties.
- Salt components.
- Volume of hydrocarbon blanket.
- Bottom of hydrocarbon blanket.
- Leach water input salinity and temperature.
- Flow rate of leach water.
- Flow rate of brine.
- Volume fraction of insolubles.
- Depth of borehole.
- Location of the suspended leaching strings at various time steps.
- Flow direction - direct or reverse.
- Oil fill or withdrawal flow rates.
- Oil/brine interface depth.

2.4.3 LEACHING

Leaching shall be accomplished in accordance with the SPR Project Performance Criteria Level II.

A slurry disposal system must be provided to handle anhydrites/particles accumulating during leaching.

2.4.4 BRINE DISPOSAL

Brine generated during leaching and operation of a solution-mined storage facility shall be disposed of by pipeline to the sea, by sale, or by injection into deep subsurface saline reservoirs. Both methods are technically feasible. Site-specific environmental and economic factors determine the best method. In the event that subsurface brine disposal endangers underground aquifers, this method shall not be used.

2.4.4.1 Brine Disposal Wells

Brine disposal wells for the SPR shall meet or exceed the requirements of Louisiana Office of Conservation Statewide Order No. 29-B and Railroad Commission of Texas Rule 9. Each well and piping shall be lined or provided with a method of preventing oxygen entry into the piping system on the well casing or provided with a corrosion inhibiting system. Disposal wells shall be completed in permeable sand formations sufficiently clear of the salt dome to preclude the dissolution of the dome edge, and sufficiently deep or isolated by aquicludes to preclude contamination of local potable water aquifers.

2.4.4.2 Brine Filtration

Brine to disposal wells may be filtered to preclude well clogging. Filtering systems shall be designed to remove 99.99 percent of suspended particles that are larger than 1/3 to 1/7 of the average disposal zone pore diameter. Where disposal zone pore diameter is unknown, the filtering system shall remove 99.99 percent of suspended particles larger than 10 microns. The flow rate of the filtering system shall be established based on the anticipated maximum brine disposal requirements of the site.

2.4.4.3 Brine Treatment

The requirement for brine treatment (sulfurization, oxygen scavenging, PH correction, etc.) prior to disposal shall be examined and equipment designed to satisfy specific treatment requirements. This equipment shall meet all other requirements within this criteria document.

2.4.4.4 Brine Pipelines

Brine pipelines shall be internally coated carbon steel or High-Density Polyethylene (HDPE) pipe. In addition to the requirements of Chapter 8, a brine discharge monitoring and instrumentation system shall be designed that meets the requirements established by the states of Louisiana and Texas, Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA), U.S. Coast Guard (USCG), Department of Transportation (DOT), and USACE. The general requirements for data transmission are contained in Chapter 14 of this criterion. An integrity testing procedure is required to insure the integrity of the brine pipeline between the site and the diffuser off-shore.

2.4.5 INSOLUBLE DISPOSAL

Insoluble disposal shall be the responsibility of the design contractor to develop the method and facilities to dispose of insolubles generated during the leaching process in an environmentally acceptable manner per Chapter 10.

CHAPTER 3

WATER/WASTEWATER SYSTEMS

3.1 PURPOSE

This chapter establishes Strategic Petroleum Reserve (SPR) design criteria to ensure that each SPR site has adequate quantities of water available, and that wastewater is treated/disposed in a sanitary and environmentally acceptable manner.

3.2 DESIGN REQUIREMENTS

3.2.1 SOURCES OF POTABLE WATER

Potable water shall be obtained from an outside source. Minimum requirements for connection shall be a flow-measuring device, a valve to isolate the system, and an appropriate backflow prevention device in accordance with the applicable sanitary code.

3.2.2 SOURCES OF PROCESS WATER

Process water for the various unit operations (salt cavern leaching, cooling and boiler water) may have raw and finished water quality specifications differing from the potable water requirements. Salt water and brackish surface and groundwater may be used for leaching and drawdown. Primary fire protection water shall be potable.

Water sources shall be analyzed to ensure that rotating equipment is specified to be compatible with water quality, and that there is an adequate supply available throughout the year consistent with cumulative SPR needs and competing appropriations for that water source. This will minimize the risk of adverse effects caused by solids and corrosion from chemicals, cavitation, and/or determine the need for water treatment or filtration.

Seal flush water for pumps shall be taken from the potable water system. A back-flow preventer shall be installed to prevent contamination of the supply. Discharge of the seal flush liquid shall be returned into the process stream or to other environmentally acceptable areas.

The raw water intake structure (RWIS) shall be designed for intake velocities at the water source interface below 0.5 FPS in order to minimize impingement of aquatic organisms and to preclude sand, dirt, etc., into the intake. RWIS screens should be of a non-corrosive and biofouling resistant material. The design of the screens shall reflect the best technology available for minimizing adverse environmental impact and include current regulatory guidelines and requirements. The designer shall provide a means to allow removal of one or more screens from service without precluding intake operation, while assuring all water is directed across remaining functioning screens. Pigging facilities shall begin at the RWIS for regular pig runs.

3.2.3 DESIGN CAPACITY

The potable water source shall be sufficient to supply a minimum of 50 gallons of water per employee per shift plus fire protection requirements. The water supply demand in gallons per minute that the system must meet shall be determined on the basis of load in terms of supply fixture units. Water pressure in the distribution main shall be a maximum of 80 pounds per square inch gauge (psig) and a minimum of 20 psig. If the minimum pressure is not available, a booster pump and pressure tank or other means shall be installed to provide adequate flow pressure. If the distribution main pressure is greater than 80 psig, a pressure reducing valve and relief device shall be installed.

3.2.4 WATER DISTRIBUTION SYSTEM

The system shall be designed to handle the demand. The maximum water velocity in the system shall be less than 10 feet per second. Service mains shall be located along roadways, and as far as practicable, mains will not be laid under areas subject to heavy traffic. Water mains shall not be located closer than 10 feet horizontally from a sewer line, except, when the bottom of the water main is 12 inches above the sewer line, a 6-foot horizontal spacing shall be permissible. Water lines shall cross a minimum of one foot above sewer lines and the sewer lines shall not have a joint for at least 10 feet on each side of the water main. A minimum of 2½ feet of cover shall be provided in grassed areas, 3 feet under driveways on roadways, and 4 feet under railroads. In all cases, the water line shall be below the frost line. Dead legs should be avoided.

All water mains and service lines shall be designed for an internal working pressure of 100 pounds per square inch (psig), plus an allowance for water hammer. External stresses for earth fill and loading shall be calculated in accordance with American National Standards Institute (ANSI) A21.1.

Pipeline strength and maintenance considerations may dictate use of the following:

- Thrust blocks at turns in the pipe to resist internal thrust loads.

- Steel casings or heavier pipe wall at roadway and railway crossings and where poor subgrade is encountered.

3.3 WASTE WATER COLLECTION

Sanitary sewer lines shall be provided from each permanent building to either a main or septic tank. Gravity service sewer lines shall be at least 6 inches in diameter and laterals and mains shall be at least 8 inches in diameter. Gravity sewers shall be laid with sufficient slope to achieve a velocity of 2 feet per second when full and 1.6 feet per second when at average flow. It is preferred that laterals and mains be located adjacent to roadways and shall follow the most feasible route to the point of disposal. All sewer lines shall be provided with at least 2 feet of cover or buried below the frost line, whichever is greater. Steel casings or heavier pipe wall can be used where the sewer line crosses roadways or railroads for strength and maintenance considerations.

If pressure sewers are used to collect and transport sewage, they shall be sized to provide a minimum velocity of 2 feet per second.

The location and cover for pressure sewers shall conform to the requirements for gravity sewers. Pressure sewers shall be laid to the contour of the site with air release valves provided at high points. The designer shall make a determination as to whether gravity or pressure sewers shall be used.

Thrust blocks may be used at turns in pressure sewers to resist internal thrust loads.

Pipe materials must meet the applicable American Society of Testing Materials (ASTM) or ANSI specifications for the material and its proposed use.

3.4 INDUSTRIAL SEWERS

Normally, special piping will not be required for industrial sewers at SPR sites. If conditions exist requiring sewer lines resistant to specific compounds, special pipe shall be specified. Specifications shall state the concentration and type of compound expected. All other design parameters except flow shall conform to the guidelines in Section 3.3. Industrial sewers shall be designed for the peak flow determined for the particular process or activity.

3.5 WASTEWATER TREATMENT

3.5.1 SANITARY SEWER

Either of two methods shall be used for the disposal of sanitary sewage: discharge to a local/regional sewer system or on-site treatment. Of the two options, discharge of sanitary sewage to a local/regional sewer system is the preferred method. When the option to discharge to a local/regional sewer system is the viable alternative, early coordination with the local utility is essential to establish tie-in and pre-treatment requirements.

When discharge to local/regional sewer systems is unfeasible, on-site treatment/disposal shall be employed. Package treatment plants, sewage lagoons, and land treatment are three types of treatment methods available. Treatment systems, which produce an effluent stream, shall be included in the site National Pollutant Discharge Elimination System (NPDES) permit (40 CFR 125, Appendix A), and any corresponding or associated state permits. Small sanitary flows may also be treated and disposed by utilizing a septic tank tile field system. This method does not produce an effluent but shall require favorable soil and groundwater conditions on the site and approval by the state or local health office.

3.5.2 INDUSTRIAL WASTES

If local/regional sewer systems will not or cannot accept industrial wastes, the waste stream(s) shall be treated on site or transported off site and disposed of in approved disposal areas. The effluent treatment system shall be designed to treat the specific waste(s) present, including hazardous compounds. Only waste effluents treated and discharged as part of a permitted wastewater treatment system and air emissions treated as part of a permitted pollution control will be treated on site when in accordance with the corresponding permits. Treatment of solid waste on

SPR sites is prohibited. Effluent from any proposed on-site treatment systems must be approved by applicable regulatory agency(ies), as documented by the corresponding site discharge permit(s) record, prior to effluent discharge.

3.6 OILY WATER

Oily wastes from pumps, valves, minor leaks and spills, de-ballasting, and any bottom sediment and water (BS&W) shall be collected and treated by an oily water treatment system prior to discharge. Treatment system discharges shall meet the specifications of Federal and State water quality codes and regulations and as a minimum consist of coalescing plate gravity-type separators. The effluent shall either be discharged to a local/regional sewer system in accordance with any applicable pre-treatment standards, or to the environment. In the latter case, the effluent stream shall be included in the site's NPDES and corresponding state discharge permit.

3.7 STORM WATER

Separate drainage systems shall be provided for storm water. Drainage systems shall be sized to handle the runoff from a 10-year storm. Either open channels or drainage pipe shall be used to divert the runoff from the site. Provisions shall be made to contain rainfall within all diked areas or other secondary containment, and then discharge the water in accordance with NPDES permit and corresponding state requirements to either the storm drainage system or to the oily water treatment system.

3.8 BRINE DISPOSAL

Brine is disposed of from SPR operations by either discharge to coastal waters or by deep well injection to a brine aquifer.

3.8.1 DISCHARGE TO COASTAL WATERS

Discharge to coastal waters may only be conducted if duly authorized by the appropriate state and or federal discharge permit. Extensive modeling has established the appropriate design criteria necessary to achieve adequate brine dispersion and diffusion in coastal waters. Discharge should be in coastal marine waters to the 30-foot contour or greater, through 3-inch diffuser nozzles at an exit velocity of 18 – 20 feet per second. Nozzles shall be on 60-foot centers along the length of the diffuser section. Brine discharge must be authorized by a federal and/or corresponding state discharge permit, as applicable at the discharge location.

3.8.2 DEEP WELL INJECTION

Deep well injection must be to an authorized zone for disposal of saltwater waste. Well design and operation must be in strict accordance with the Underground Injection Control (UIC) requirements for such class II wells, as specified by the applicable Federal or delegated State programs. The designer should refer to those specific UIC requirements for minimal design specifications. When using commercial wells, SPR wastes should only be mingled with like regulated waste streams.

CHAPTER 4

ONSITE MECHANICAL SYSTEMS

4.1 PURPOSE

The requirements in this chapter pertain to the design, preparation of plans, and specifications for onsite process and special mechanical systems and piping. Instrumentation and controls for such systems shall provide alarms, interlocks, fail-safe hardware, and safe startup and shutdown design features and hardware. Corrosion prevention and decontamination control must be provided.

4.2 DESIGN REQUIREMENTS

4.2.1 ONSITE PIPING SYSTEMS

4.2.1.1 General

Pipe sizes smaller than 1/2 inch shall not be used.

Carbon steel pipe sized 1¼ inches, 3½ inches, 5 inches, 7 inches, 9 inches, etc., shall not be used except for connecting to equipment or where velocities must be maintained.

All lines shall be provided with vents and drains as required.

Where a specification break occurs between two connecting lines, the higher specification shall include the first block valve adjacent to the lower specification line.

All piping systems shall be designed so that the loads and moments applied at the flanges of mechanical equipment shall not exceed reasonable reactions for equipment of comparable size as determined by codes, as applicable, and by information obtained from manufacturers of the equipment.

Provisions shall be made to prevent stresses (including thermal expansion) in piping and bolting beyond design codes. Piping shall be designed to accommodate subsidence and differential settling.

Piping at all equipment shall be separately supported so that connected equipment does not support the piping. This permits equipment removal without further supporting the piping and with minimum dismantling. Pump piping flanges shall be installed such that no pipe stresses are transmitted to the pump.

Where required, thrust blocks will be used at turns in pipelines to resist internal thrust loads.

Piping at pump stations and caverns shall have permanent accommodations for flow measuring devices as required in Chapter 14.

The use of dissimilar metal combinations in water and brine piping, flange and piping support installations is prohibited without the inclusion of positive steps to eliminate the galvanic corrosion of the less noble material. The steps should include electrical isolation of the dissimilar metal combination with insulating flanges in piping, Teflon pads between piping and supports, and the use of cathodic protection as applicable.

4.2.1.2 Instrument Tubing

Instrument tubing shall conform to the industry codes and standards. Tubing and connections smaller than 1/2 inch shall not be used for instruments unless a smaller size connection is provided as standard on instrument manufacturer's equipment. All instrument tubing shall be designed to resist corrosion.

Pressure connections to pumps, process lines and equipment having screwed connections shall be supplied with a stainless steel bar stock block valve with male screwed end between the tapped connection and the first instrument.

All tubing used for instruments shall be in accordance with the applicable material classification and shall be shown on the Piping and Instrumentation Diagrams (P&IDs) as follows.

- Through the first block valve for pressure connections to pressure and flow instruments and analyzers.

- All tubing for gauge glasses and level control instruments.

- Through the first block valve for pressure gauges in services included in the piping material classifications.

Level gauges and level instruments shall be installed with separate vessel connections and shall be accessible from grade or platform. Specific process instrument arrangements shall be installed in accordance with the design presented and shown on the P&I diagrams. Instrument tubing shall be provided with block and bleed valves to allow removal of instruments without shutting down system.

Instrumentation fittings and gauges will be secured, guarded, or otherwise protected to minimize the possibility of breakoff due to vibration, collision, or other mechanical damage. For crude oil and brine instrumentation, the design shall consider flow-limiting devices, such as orifices, to limit fluid loss if piping or instruments are damaged or broken off.

4.2.1.3 <u>Onsite Piping</u>

Consideration should be given to above ground installation of onsite piping. Table 4-1 indicates appropriate codes/specifications for design requirements. Buried piping, valves and fittings shall be protected in accordance with National Association of Corrosion Engineers (NACE) standards and Sandia National Laboratories (SNL) report. A minimum corrosion allowance of 0.125" shall be used for crude oil piping and 0.22” for raw water and brine piping.

TABLE 4-1

DESIGN CODES AND SPECIFICATIONS

	WELLHEAD		ONSITE PIPING & FACILITIES			
	CO	RW/BR	CO	RW/BR	FW & FF	ALL OTHERS
DESIGN	API 6A API 6D	API 6A API 6D	CFR 49 PART 195 ASME B31.4	ASME B31.4	ASME B31.3 NFPA 12, 15, & 24	ASME B31.3
PIPE/CASING	API CT API 5D API 5L	API CT API 5D API 5L	ASME B31.4	ASME B31.4	Per NFPA	Per B31.3
FLANGES	API 6A ASME B16.5	API 6A ASME B16.5	ASME B16.9 MSS-SP-44	ASME B16.9 MSS-SP-44	ASME B16.1 ASME B16.25 ASME 16.5 UL or FM	ASME B16.9 MSS-SP-44
FITTINGS	API 6A	API 6A	ASME B16.9 ASME B16.11 MSS-SP-75	ASME B16.9 ASME B16.11 MSS-SP-75	ASME A21.10 ASME B16.9 & B16.11 UL or FM	ASME B16.9 ASME B16.11
VALVES	API 6A API 6D	API 6A API 6D	API 6D ASME B16.34 API 600 API 602	API 6D ASME B16.34 API 600 API 602	NFPA, UL or FM MSS-SP-80	ASME B16.34 API 600 API 602 API 6D
WELDING PROCEDURES AND WELDER QUALIFICATIONS	ASME IX API 6A	ASME IX API 6A	CFR 49 PART 195 & API 1104 ASME IX	ASME IX or API 1104	ASME IX	ASME IX
WELD ACCEPTANCE AND INSPECTION CRITERIA	API 6A	API 6A	CFR 49 PART 195 & API 1104 (1)	API 1104	ASME B31.3	ASME B31.3

LEGEND
C0 - CRUDE OIL
RW - RAW WATER
SF - SEAL FLUSH
BR - BRINE
FW - FIRE WATER

For underground piping installed in pipe trenches, lines shall be installed side by side in the trenches. Underground flanges should be avoided; however, if used, the lowest point of all flanges of lines shall be 3 inches minimum above the bottom of the trench and 4 inches minimum from the side of the trench. There shall be sufficient clearance between lines to permit ready access for removal and/or repairs and in no instance less than 2 inches between a pipe and the outside of the largest flange or fitting in the adjoining pipe. All valves and instruments buried or in trenches shall be protected from corrosion, freezing, and standing water exposure.

Exposed piping shall be supported per the applicable piping codes and not be overstressed, during thermal, storm or upset conditions.

Lines may be carried side by side on overhead pipe supports. Sufficient clearance shall be allowed between lines to permit ready access for removal and/or repair and in no instance shall there be less than 1 inch between a pipe and the outside of the largest flange or fitting in the adjoining pipe spacing. All gravity drain piping shall be installed with continuous slopes. Pressure piping shall be installed level with low points minimized.

Standard specifications for piping classification and service shall be established, to include associated fittings, flanges, bolting, gasketing, valves, etc.

4.2.1.3.1 **Fittings**. Fittings shall conform to the standards listed in Appendix A and Table 4-1, as applicable.

4.2.1.3.2 **Flanges**. Flanges shall conform to the standards listed in Table 4-1, as applicable. In general, flanges 1/2 to 1-1/2 inches shall be raised-face, socket-welded (RFSW); 2 inches and greater shall be raised-face, weld-neck (RFWN).

4.2.1.3.3 **Gaskets**. Gaskets shall conform to the flange requirements set forth in Table 4-1. Gasketing material shall be compatible with the process condition in accordance with the standard specification. Asbestos shall not be used.

4.2.1.3.4 **Bolting**. Bolting shall be alloy steel, stud bolts, and nuts, with a corrosive inhibiting coating.

4.2.1.4 Vents, and Drain Piping

All process piping shall be equipped with vents at the high points and drain lines at the low points. Valves and connected piping shall be provided in accordance with applicable codes.

The discharge side of vent or drain valves not piped into a closed vent or drain system shall be plugged or flanged when not in use.

Unless unique site-specific requirements dictate otherwise, all venting of hydrocarbon vapors and all discharge of hydrocarbons from process piping and equipment shall be piped into closed vent or drain systems.

4.2.1.5 Insulation

Piping and equipment containing liquids subject to freezing or increase in viscosity shall be adequately protected by insulation. For non-critical systems subject to freezing, installation of adequate drains, to allow for emptying the lines ahead of freezing temperatures, is acceptable. Thickness of insulation shall be determined on an individual basis for the expected minimum ambient temperature at the plant site and the properties of the liquid under consideration. Insulation design shall eliminate or mitigate corrosion under insulation (CUI).

4.2.2 RELIEF SYSTEMS

Pressure relieving systems and devices shall be sized, selected and installed per API 520, “Sizing, Selection and Installation of Pressure Relieving Devices”.

The size of individual discharge lines from relief valves relieving to atmosphere or into a common header shall be at least the same size as the valve outlet.

The size of a common relief header shall be such that any pressure that may exist or develop in the relief system will not reduce the relieving capacity of any relief valve below that required to properly protect the system.

4.2.3 PUMPS

4.2.3.1 General

Centrifugal process pumps and drivers shall be in accordance with American Petroleum Institute (API) 610, API 614, API 670, (instrumented per the Control System Functional Specification, MS-I-910-006), API 671, API 682, and NEMA MG-1. Pumps and drivers shall be designed for the specific service and process conditions.

For pumps in crude oil service the pump must be designed to pump the lightest oil allowed per Level 1 Criteria, Appendix C, and the driver for the pump must be designed for the heaviest oil allowed per Level 1 Criteria, Appendix C. For pumps used for filling caverns the pumping system must be designed to fill full caverns at rates necessary to support the fill rate specified in Level 1 Criteria Appendix A.

Auxiliary and utility water pumps shall be designed to ASME B73.1, except service requirements might be for intermittent operation.

Centrifugal process pumps larger than 1500 hp, capable of remote start shall be provided with an automatic local pre-startup alarm and shall be of forced lubrication design with interlocks to prevent “dry” starts.

4.2.3.1.1 Materials for lift, booster and injection pumps in crude oil, raw water and brine service shall be compatible with the fluid service. The impeller, wear rings, shaft, shaft sleeve and seal gland shall be of material that resists corrosion and erosion under operating conditions. Crude oil pumps should utilize S-6 construction materials, raw water pumps should utilize D-1 construction materials and brine pumps should utilize A-8 (317L) SS construction materials per Table 4-2.

TABLE 4-2
SPR PUMP MATERIAL (API 610)

SERVICE	CRUDE OIL	RAW WATER	BRINE
API 610 MATERIAL CLASS	S-6 (1)	D-1 (2)	A-8 317L SS (3)

(1) 4140 SHAFTS, NITRONIC 50 CASE WEAR RINGS AND NITRONIC 60 IMPELLER WEAR RINGS.
(2) DUPLEX SS SHAFTS, DUPLEX SS CASE WEAR RINGS AND DUPLEX SS (HARD) IMPELLER WEAR RINGS.
(3) NITRONIC 50 SHAFTS, STELLITE 6 HF 316 CASE WEAR RINGS AND STELLITE 6 HF 316 IMPELLER WEAR RINGS, OR NITRONIC 50 CASE WEAR RINGS AND NITRONIC 60 IMPELLER WEAR RINGS.

4.2.3.1.2 Process pumps shall normally be horizontal, centrifugal, axially split-case type, and capable of series operations, unless site-specific conditions create unique requirements.

4.2.3.1.3 Pumps shall be supplied with seal flushing plans in accordance with API 610 and API 682. Crude oil pumps shall be supplied with plan 54 with 100% spares for each group of pumps at a given site. Plan 54 seals shall have leakage detection included in a console plus a redundant spare console, provided for each bank of pumps. Raw water and brine pumps shall be supplied with seal flush plan 32. Pumps using plan 32 shall be supplied with clean water filtered with 40 mesh screens passing particles smaller than 420 microns. Sufficient space shall be provided on pump shafts to accommodate the mechanical seals.

4.2.3.1.4 Centrifugal pumps shall be used for oil pumping service unless special considerations dictate otherwise. The set pressure of PSV's provided for piping system over pressure protection shall be based on the maximum design pressure of the pump casing or the piping, whichever is less. Centrifugal main oil pumps shall use mechanical seals equipped with leak detectors. Pumps shall be selected in accordance with hydraulic requirements, and trimmed impellers may be used as required for operations. A positive displacement pump shall be used where the duty cannot be efficiently performed by a centrifugal pump. Where a positive displacement pump is used, it shall be fitted with a by-pass relief valve located on the port provided by the manufacturer or upstream of the pump discharge valve. The relief liquid shall be routed back to the suction source or a tank.

4.2.3.1.5 Pumps shall be factory equipped with bearing and case temperature detectors and vibration detectors, in accordance with API 670 (instrumented per the Control System Functional Specification, MS-I-910-006), all prewired in metallic wiring system enclosures shall be rated per the area electrical classification.

4.2.3.1.6 Loading pumps, transfer pumps, etc., shall be selected for their specified head and flow requirements. These pumps may be horizontal or vertical, single or multi-stage, driven by electric motors. Pump units shall be factory assembled, tested, and supplied as integral units for direct installation and hook-up with minimum additional assembly required in the field.

4.2.3.1.7 In the interest of standardization, the number of different types and sizes of pumps, motors, etc., shall be kept to a minimum. Motors from National Electric Code (NEC) or API 500, Class I, Division I, must be explosion-proof and must be labeled as such. Pumps from API 500, Class I, Division II, must be totally enclosed fan cooled (TEFC) or totally enclosed, air-to-air cooled (TEAAC).

4.2.3.1.8 The provision of standby equipment and their drivers shall be specified, taking into consideration the maintenance and operating requirements. Maximum use shall be made of common standby pumps. Where standby pumps are not to be installed initially, space shall be left for their future addition unless otherwise specified.

4.2.3.1.9 Facility design shall incorporate Occupational Safety and Health Administration (OSHA) and other regulatory acoustical requirements.

The designer shall, in his equipment specifications, fully detail the standards, procedures, techniques, and allowable margins applicable to noise measurement. Vendors shall, when quoting for supply of equipment, furnish data on noise performance. Mitigative measures shall be provided if the 85 dB industry standard for noise control will not be met. Factory and field-testing and performance shall also be made a part of the supply contract as applicable.

4.2.3.1.10 Horizontal pumps and drivers shall be mounted on a common baseplate of rigid construction. Pump and motor mountings shall be flat to within 0.0005 in./ft. (applies to all pads relative to each other). Generally, pumps and support equipment should be located in the open and preferably near the equipment, which they serve. For explosion and fire protection, consideration shall be given to including physical separation between (among) individual pumps. Pumps shall be located at or near grade level and should be readily accessible for "in situ" maintenance or removal to the workshops if pumps are covered.

4.2.3.1.11 Flexible couplings between the pump and motor shall be in accordance with API 671. Hydraulically mounted couplings with tapered shafts are required. Gear type couplings shall not be allowed.

4.2.3.1.12 Instrumentation required for major pumps and drivers shall normally include the following monitors. Refer to the Control System Functional Specification, Document MS-I-930-006 for specific requirements.

- Suction and Discharge Pressure Indicating Gages
- Vibration Detector
- Suction Pressure-Low
- Running Time Meters
- Bearing Temperature-High
- Flow Alarm-Low
- Seal Leak
- Pump Casing Temperature-High
- Motor Winding Temperature-High (Electric Driven)

The separately provided control equipment activated by these monitors shall be designed in accordance with the facility operational philosophy. Either "Alarm Before Shutdown," or "Alarm and Shutdown," shall be provided, depending on operating conditions.

4.2.3.1.13 Space heaters shall be supplied to maintain the interior of the motor enclosure above the dew point. Heaters shall be unaffected by the accumulation of moisture under severe weather conditions. Heaters shall be mounted on noncombustible material and shall operate without thermal damage to the motor or themselves. Heaters rated 800 watts and less shall be rated 120 volts, single-phase. They shall have a maximum sheath temperature of 160°C. Leads for the heaters shall be brought out into a terminal box separate from the main power leads terminal box. Where specified, redundant heaters shall be provided to prevent loss of protection after failure of any one heater.

4.2.3.1.14 All pumps handling hydrocarbons or other flammable fluids or fluids whose escape would constitute a serious hazard shall have steel casings except where otherwise specified.

4.2.3.1.15 All centrifugal pumps shall have characteristic curves exhibiting a decrease in head with increasing capacity.

4.2.3.1.16 Where a centrifugal pump is driven directly through a gearbox, the vendor shall present his critical speed analysis for the complete set of pump and driver to show that the torsional or lateral critical speeds for the driver, pump and transmission (as a complete coupled set installed on site) are outside the operating speeds by the margins stated in the relevant specification. The vendor shall then provide the supporting data to this effect. Furthermore, no torsional or lateral critical speed shall occur within the speed range of 70 percent of the normal operating speed to 110 percent of trip speed.

4.2.3.1.17 Pumps shall be factory tested for head, flow, power requirements, efficiency, and net positive suction head (NPSH) requirements. Certified factory test curves and data shall be supplied for permanent records. All pump cases shall be hydrostatically tested to no less than 150 percent of anticipated station pressure unless otherwise specified.

4.2.3.1.18 Hydrodynamic (radial and thrust) bearings shall be applied when the radial and thrust bearing speed or life are outside the limit for rolling element bearings or the pump energy density is above the limits set in API-610.

4.2.3.1.19 A forced feed lubrication system in accordance with API 614 shall be provided for all process pumps larger than 1500 hp driven by medium voltage (4160V) motors.

4.2.3.2 **<u>Mechanical Seals</u>**

Where required, pumps shall be furnished with mechanical seals. Seals shall be single balanced seals sized for maximum operating pressures. The seals are to be furnished to meet API 682. The seal ring material shall be a suitable for the service, for instance, use silicon carbide vs. silicon carbide for the inner seal and silicon carbide vs. carbon for the outer seal of crude oil pumps. Use silicon carbide vs. silicon carbide for raw water and brine pumps. All identical pumps shall be provided with the same brand and type seal.

Pump manufacturers shall meet all the conditions of stuffing box circulation, cooling, and pressure required by the mechanical seal manufacturer for the satisfactory operation of the seals.

4.2.3.3 Rotary Pumps

When rotary pumps are used for handling liquids having poor lubricating properties, it must be ensured that working parts of such pumps do not rely solely on the process fluid for satisfactory operation. Another source of lubrication shall be specified. Also, when the bearings of rotary pumps are not lubricated by the pumped fluid but use another source, the design shall ensure that there is an adequately drained cavity between the stuffing box(es) and the bearings. Grease lubrication of such bearings may only be used where the pumping temperature does not exceed 240°F. In specifying rotary pumps, the degree of risk from solids contamination shall be assessed.

4.2.4 VALVES

All valves shall conform to the appropriate API and ASME specifications, and the designer shall cite separate specifications for wellheads and onsite process and pipeline valves. Where size and service requirements dictate, valve shall have replaceable seats for maintainability when the diameter is greater than 2-inches. Valves greater than 4 inches in diameter shall have replaceable seats and removable bonnets. All valves shall be new and of recent manufacture.

Used or repaired surplus valves are not acceptable. Valve components (body, stems, rings, seals, etc.) shall be compatible with the liquid serviced. Consideration shall be given to corrosion/erosion effects of material used. Standardized SPR valves shall be used where possible.

4.2.4.1 <u>Block Valves</u>

Valves shall be cast, forged, or fabricated steel for class 150 and higher.

4.2.4.1.1 Use fabricated slab gate type valves with double isolation and bleed feature, for tight shut-off service and the following applications: (1) pipelines, (2) where pigging is required, and (3) manifolds and headers larger than 24 inches.

4.2.4.1.2 Use full-bore, trunnion-mounted, ball-type valves with double isolation and bleed feature for tight shut-off service and the following applications: (1) pipelines, (2) where pigging is required, (3) manifolds and headers 24 inches or smaller, and (4) restricted space in the stem axis.

4.2.4.1.3 Use double expanding-type wedge gate valves or ball valves with double isolation and bleed feature as cavern isolation valves.

4.2.4.1.4 Use wedge gate type block valves or ball valves on pump suction and discharge applications. Use wedge gate block valves at other locations when slight internal by-pass leakage is acceptable. Sizes large than 24 inches are acceptable only for restricted space in the stem axis.

4.2.4.2 <u>Check Valves</u>

Check valves shall be cast, forged or fabricated steel and either conventional swing check, double door check, or tilting disc check valves of a class governed by service conditions. In primary service, slam retarders closing the valve at zero flow conditions or intrinsically non-slam design is required to prevent reverse rotation of pumps or damage of equipment produced by slamming of the clapper.

4.2.4.3 Double Block and Bleed Valves

Double block and bleed valves or double isolation and bleed of proven design as appropriate shall be used on meter proving installations and where otherwise necessary to avoid product contamination and to eliminate a hazardous condition.

4.2.4.4 Control Valves

Control valves for pressure and flow control shall be cast or forged steel, and of a type designed for throttling service. Control valves shall have electrically driven operators. Gate valves shall not be used for motor operated throttling service. Where manual throttling is necessary, a globe valve with guided disc, plug or a ball valve should be used.

4.2.4.4.1 Use full bore, trunnion mounted ball type valves with metal-to-metal seats for throttling the flow of raw water or brine with low to moderate pressure drop, higher flow capability when full open and equal percentage inherent flow characteristics and freedom from plugging are a consideration. Ball valves have a Liquid Pressure Recovery Factor (F_L) that is lower than that for a globe valve and therefore are more prone to cavitation.

4.2.4.4.2 Use ball valves with anti-cavitation trim for throttling applications with moderate pressure drops, equal percentage or linear inherent flow characteristics when plugging of the valve is not a consideration. Use globe type valves for throttling applications with equal percentage or linear inherent flow characteristics when plugging of the valve is a consideration.

4.2.4.4.3 When flow conditions, which when controlled will cause severe or persistent cavitation, based on experience or preliminary calculations, specialized custom designed valves supplemented with pressure reduction devices such as orifice plates as required shall be used to prevent the damage caused by cavitation. A heuristic approach is required for the elimination of cavitation. All design of valves for throttling applications shall consider the possibility of plugging.

4.2.4.5 Relief Valves

Relief valves shall be cast or forged steel and installed, as necessary, to limit the maximum pressure in piping and equipment. Thermal relief valves shall be installed in lines, which can be closed in so that pressure caused by thermal expansion of the fluid in the pipe can be relieved. All relief valves shall be designed to API 520 Sizing, Selection and Installation of Pressure-relieving Devices and API 521 Pressure Relieving and Depressuring Systems.

4.2.4.6 Motor-Operated Valves

All motor-operated valves shall have actuators of a standardized integral control type equipped with phase-discriminators. Motor operated valves shall have the capability of reversing the travel locally or remotely from the Central Control Room (CCR) without having to first complete travel to a fully open or closed position.

4.2.4.7 Installation.

Orientation and location of valves shall permit easy access for operation and maintenance. Motor operators, hand wheels or stems shall not obstruct platforms or walkways. Where valves are installed aboveground, hand wheels and operators shall be accessible from grade or from permanently installed access platforms. Where valves are installed below ground, body bleeds, seal injection fittings, and packing injection fittings shall be aboveground. Hand wheels and operator controls shall be approximately 3 feet above grade.

4.2.4.8 **Manual Gear Drivers.**

Manual gear drivers shall be provided for all valves 6-inches and larger when not equipped with motor operators.

4.2.5 FLARE SYSTEM

Any flare system should be a self-supported, integrated flare with air assist to provide smokeless burning. The system shall include a knockout pot, a water seal flame arrestor, a blower, burner head, pilot, ignition system, complete set of controls, and a self-supported stack. The system shall be designed to provide essentially 100 percent combustion of all hydrocarbons in the vent gas stream. This system shall meet all environmental requirements. The water level in the flame arrestor shall be automatically maintained at a safe level. Flares shall be placed away from buildings and populated areas. Radiation levels shall comply with API recommendations.

Flares shall be in compliance with API 521 Guide for Pressure Relieving and Depressuring Systems and with API 537 Flare Details for General Refinery and Petrochemical Service.

CHAPTER 5

ELECTRICAL SYSTEMS

5.1 PURPOSE

This chapter establishes design requirements and guidance to provide electrical designs that are complete, safe, reliable and compatible with the site functions which they support.

5.2 DESIGN REQUIREMENTS

Electrical design shall comply with the standards and codes in Appendix A except as stated in the following sections.

Electrical systems shall be designed to industry standards and be operated and maintained to avert injury to personnel and/or damage to itself or other facilities in event of normal or abnormal operation.

All plans and specifications shall be reviewed for conformance with established codes, standards and principles before submitting to DOE SPRPMO for review or acceptance.

A complete design analysis for new design modifications that affect load flow or short circuit capacity shall be completed for the design. The analysis shall include a short circuit study with coordination settings for all protective devices.

Early contact shall be made with the appropriate electrical power company to identify the work required to supply power to the SPR complex in a timely manner. Design must take into consideration the minimum power factor.

Use of dissimilar metals in the power, instrument, control, or grounding systems shall be minimized. Where dissimilar metals are used, ensure the connection point is not sacrificed.

5.3 SPECIFIC REQUIREMENTS

5.3.1 MAIN SUBSTATION AND SWITCHGEAR

5.3.1.1 The main substation serving the site and its switchgear shall have a split-bus configuration with a minimum of two transformers. The substation and switchgear shall be designed to exceed capacity to meet all electrical demand for maximum drawdown requirements. All switchgear, circuit breakers, and fuses shall be sized for continuous and fault current requirements. The main substation shall be complete with transformers, switchgear, protective relays, metering, lighting, feeders, equipment, pads, fencing, grounding, lightning protection, and tie-ins to commercial power lines as required. The substation shall be supplied by a primary loop, or by two separate sources with two physically separated incoming lines at or above 15 Kilovolt (KV) nominal when available and/or economically feasible. Incoming lines above 15KV shall be switched using oil, SF6 gas or vacuum circuit breakers and with isolating switches. Unless otherwise specified, transformer secondaries shall be 4,160 volts with 5KV vacuum for main, tie, and feeder breakers protecting 5KV feeders.

The main substation transformers shall be protected by either motor-operated SF6 circuit-switchers, vacuum switches, or SF6 gas circuit breakers on the primary side and arranged to permit connection to either incoming power line (if applicable) to provide the maximum availability of site power. Transformers shall be provided with automatic load tap changers when required to maintain five percent voltage regulation. The transformers shall be sized to carry the sum of the calculated maximum demand loads even when one main transformer is out of service. Transformers shall be outdoor oil filled substation type and shall be connected delta-wye with a low "R" neutral resistor provided at the transformer. Oil-filled transformers shall be separated from other units and buildings, structures, or equipment subject to fire damage as required by FM. Fire suppression in case of an oil leak shall be accomplished in accordance with FM requirements. Transformers shall be surrounded with oil containment areas. Substations shall generally be fence-enclosed, low-profile, with aerial incoming lines, open tubular busses, enclosed bus duct, or underground secondary feeders as applicable inside the fence. Substations shall be grounded and provided with air terminals and surge arrestors for lightning protection. Protective relays shall be selectively coordinated with the commercial power company and secondary substations to minimize interruptions due to fault currents.

5.3.1.2 **Medium Voltage Switchgear**

Switchgear for circuits above 600 volts shall be indoor metal clad type or manufacturer's standard design to be installed in an environmentally controlled building. Switchgear shall be in National Electrical Manufacturers Association (NEMA) 2 enclosures if installed in a building having automatic water sprinklers. Switchgear shall be of arc-resistant construction per IEEE standard C37.20.7 with appropriate plenum design per manufacturer's recommendation. Switchgear shall consist of dead-front structures with removable electrically-operated circuit breakers. Switchgear shall consist of motor operated remote racking of circuit breakers for increased personnel safety. Circuit breakers shall be vacuum-type with stored energy mechanisms. Switchgear shall be used for the following services:

- Main incoming line or transformer primary feeder breakers, as required.
- Manual tie breakers.
- Motor control center (5KV) feeders.

A minimum of one spare circuit breaker cubicle with breaker shall be included for future service. Lightning Surge protection shall be provided via surge arrestors installed at the line side of main breakers as well as the load side of the feeders.

5.3.1.3 Secondary Substations (480V)

Secondary substations shall generally be double-ended indoor articulated unit substations with dry-type, or liquid cooled transformers; drawout, manually-operated feeder breakers; and automatic, interlocked, electrically-operated main and tie breakers where required to meet the reliability, availability, maintainability (RAM) requirements.

5.3.1.4 Pad-Mounted Distribution Transformers

Outdoor pad-mounted transformers shall be tamper-proof, oil-filled, or dry type, transformers feeding indoor or outdoor, single- or double-ended motor control centers, switchgear or switchboards. Pad-mounted distribution transformers shall have stainless steel enclosures and shall also be used to serve outdoor switch racks and indoor power distribution centers.

5.3.1.5 Medium Voltage (5KV) Motor Controllers

Medium voltage (5KV) motor controllers shall be NEMA Class E2 design and grouped into motor control center line-ups of manufacturer's standard design to be installed in an environmentally controlled building. Controllers shall be in NEMA 2 enclosures if installed in a building with automatic water sprinklers. New motor controllers shall be arc-resistant and shall be fused-type employing current limiting power fuses and shall have a minimum interrupting capacity of 350 MVA symmetrical at 4160 volts. Line contactors shall be either vacuum-type and magnetic controlled. Each controller shall be complete with all required protective relays, auxiliary relays, and standard accessories.

In general, larger motor control centers shall be furnished and arranged for future expansion on each end, with space provided for two future cubicles on each end and shall have the incoming line section in the center of the line-up. Smaller motor control centers (e.g., 10 motor controllers or less) shall be arranged for future expansion on one end as a minimum, with space provided for a minimum of one and a maximum of two future cubicles and shall have the incoming line section at the opposite end of the line-up. For large line-ups, MCC's which are "close-coupled" to switchgear are allowed.

5.3.2 PRIMARY AND SECONDARY DISTRIBUTION

All elements of the transmission and distribution system shall be properly designed to limit over-voltage due to surges or voltage spikes, to prevent damage or significant reduction in operating life.

The 5kV and 480V Electrical systems shall include energy-reducing maintenance bypass switching, energy-reducing active arc flash mitigation systems, high resistance grounding, and current limiting devices to improve electrical safety.

All cabling shall be installed above ground whenever possible. Direct burial cabling should be avoided. Design shall preclude shutdown of facility operations due to high voltage surges, low voltage, high currents, or excessive heating. The power distribution system shall limit the voltage drop at each service or motor based on motor starting conditions and based on steady state conditions.

5.3.2.1 Primary (5KV) distribution shall consist of overhead cross arm or armless construction; enclosed bus ducts; cable bus system; aluminum or fiberglass cable tray or conduit-mounted on overhead pipe racks; or red concrete encased underground duct banks with manholes and PVC conduit. Above ground duct bank monuments shall be used as required to provide a safe, reliable, maintainable, and economical distribution system.

Cable tray or conduit mounted on overhead pipe racks is the preferred distribution method. Cable trays and pipe racks shall be carefully coordinated to avoid interference with normal or emergency operating or maintenance traffic requirements, including firefighting equipment and use of water monitors. Overhead cross arm or armless construction shall not be used within 50 feet of a hazardous area as classified in American Petroleum Institute (API) RP 500.

5.3.2.2 Secondary distribution shall be either underground or in cable trays. Underground distribution where utilized shall employ cable approved for wet locations and installed in PVC conduit in duct banks with above ground monuments.

5.3.2.3 Low voltage (600 volt and below) power and instrumentation cables may be installed in the same cable tray that shall have well defined and properly segregated troughs which are well marked to prevent accidental cuttings and to minimize electromagnetic interference.

5.3.2.4 The conduit system shall be designed using the NEC as minimum standards.

5.3.2.4.1 Rigid galvanized steel conduit, corrosion-treated electrical metallic tubing, or aluminum conduit shall be used as permitted by codes. PVC-coated conduit or copper-free aluminum conduit shall be used in outdoor installations. Nonmetallic conduit, such as rigid Polyvinyl Chloride (PVC) conduit, shall be used for underground installations encased in red concrete. Where nonmetallic conduit is used, the transformation to metallic conduit shall be made under-ground using a PVC-coated RGS conduit elbow when leaving a duct bank to go above ground.

5.3.2.4.2 Flexible metal conduit shall be installed as specified by the NEC.

5.3.2.4.3 Minimum size conduit shall be 1-inch underground and 3/4-inch aboveground except that 1/2-inch size may be used for short drops to instruments, lighting fixtures, or where the conduit is an integral part of the equipment. No conduits shall be reduced in size below grade.

5.3.2.4.4 All electrical equipment, conduit installations and wiring methods in hazardous locations shall comply with Articles 500 and 501 of the NEC.

5.3.2.4.5 Exposed conduit shall run parallel or at right angles to beams and walls and shall be properly fastened to structures. Horizontal conduits supporting pendant fixtures shall have conduit clamps installed as near to the fixture as possible. Plastic switch, receptacle, and junction boxes shall not be used.

5.3.2.4.6 Seal and drain fittings shall be provided in conduit lines that start at elevations substantially above grade and terminate in explosion-proof equipment, control houses, and similar structures at a point below starting elevation. Drain fittings shall be installed at the low point above grade. Drain fittings shall be provided on the outdoor equipment enclosures to prevent accumulation of condensate, such as on motor controllers, circuit breakers, lighting panels, relay boxes, and motor enclosures.

5.3.2.5 <u>Conductors</u>

The allowable current-carrying capacity of conductors shall be as specified in the NEC.

5.3.2.5.1 Feeders to distribution centers and transformers shall be sized based upon the maximum demand of initial loads. Feeders shall have a current-carrying capacity equal to 125 percent of the maximum demand or nameplate rating whichever may be the greater.

Subfeeders from distribution centers to load shall be sized in accordance with the NEC.

5.3.2.5.2 Conductors shall be sized to limit voltage drops during steady-state conditions as follows:

- Feeders -------- 2% based upon maximum demand
- Subfeeders ------- 3% based upon nameplate
- Motor Branch Circuits ------- 3% from the power center to the motor (using Motor nameplate)
- Lighting Branch Circuits ------- 3% from the panel to the farthest outlet

For circuits above 600 volts, the minimum conductor size shall be the smallest practical size dictated by the full load current of the connected load and the allowable conductor temperature rise under short circuit current.

For lighting and power circuits 600 volts and below, the smallest wire size shall be #12 AWG except that #14 AWG may be used for controls, control panel wiring, or wiring that is an integral part of the equipment where tensile strength does not require #12 AWG.

All conductors #8 AWG and larger (other than type M) shall be stranded. Conductors #10 AWG and smaller may be stranded or solid.

The motor starting conditions shall be analyzed to determine the impact on the system voltages. The calculated voltage drops shall not exceed the recommendation from the manufacturer of the respective electrical equipment being served. In general, a maximum of 20% voltage drop at each bus shall be used as a guideline for motor starting conditions.

5.3.2.5.3 Conductors shall be constructed as follows:

- For use above 600 volts, conductors shall be shielded type, terminated with stress cones and grounded in accordance with manufacturer's recommendation and rated at or above the system voltages. Insulation shall be per NEC.

- For use below 600 volts, conductor insulations shall be type THWN/THHN or XHHW. Current capacity shall be based on the 75^{o} C rating.

- For fixture stems, stranded fixture wire shall be used to meet temperature requirements.

- All conductors shall comply with applicable portions of Insulated Cable Engineers Association (ICEA) Standards.

- All conductors shall be copper (specify appropriate American Society for Testing Materials (ASTM) copper grade).

- Generally, field splices are not desirable. When required, splices shall be in accordance with the NEC.

5.3.3 EMERGENCY POWER

5.3.3.1 Emergency power shall be provided by one or more piston engine driven generator(s). Provisions shall be made for selecting automatic battery start and automatic transfer or remote battery start and remote transfer via the Distributed Control System (DCS) from the Central Control Room. All necessary auxiliaries including fuel tanks, battery chargers, metering, static or brushless rotating exciter, synchronizing equipment, governors, and voltage regulator shall be included. The system shall be sized to carry all critical loads including the Uninterruptible Power System (UPS) and shall be capable of supplying power to sequentially shut down the site in a safe and orderly manner.

Critical loads include instruments, control systems, emergency lighting, computers, security systems, fire alarm systems, communication systems, MOV's essential for an orderly emergency shutdown of individual pumps or the plant, data and status collection circuits, some of the air handling and air-conditioning systems, the battery charging system for the substation DC relaying and equipment operation power, and the 125V DC system for the three main site load centers.

The system shall be capable of operating for 72 hours on system fuel, with refilling of fuel tanks possible without system shutdown.

5.3.3.2 The UPS shall be a unitized system consisting of an Alternating Current (AC) rectifier and battery charger. The UPS shall be capable of supplying power to sequentially shut down the site in a safe and orderly manner. UPS batteries shall be sized to carry full critical loading for a minimum of 60 minutes.

5.3.3.3 In sizing the emergency power and UPS systems designer shall employ a 1.5 growth factor.

5.3.4 LIGHTING SYSTEMS

Energy conservation shall be considered in lighting design. General lighting levels shall be per Illuminating Engineering Society of North America (IESNA) guidelines.

5.3.4.1 Emergency Lighting

5.3.4.1.1 A sufficient number of light fixtures shall be connected to the emergency power system and spread throughout all areas to facilitate an orderly and safe shutdown and personnel evacuation. Emergency Exit signs shall be LED type to reduce power consumption and extend life.

5.3.4.1.2 The control, laboratory, and equipment rooms shall be provided with an appropriate number of battery-operated emergency units.

5.3.4.1.3 The emergency lighting system shall meet the applicable OSHA requirements 29 CFR 1910, Section 1910.308(b)(3) and National Fire Protection Association (NFPA) 101.

5.3.4.1.4 Emergency generators shall be used for all critical lighting and hotel loads. Battery backup shall be required for exit signs and building emergency lighting in the event that the emergency generator is not operating.

5.3.4.2 Design

5.3.4.2.1 The lighting design for outdoor facilities shall be based on the maximum use of photoelectric controlled, light-emitting diode (LED) lighting.

General lighting levels shall be per American Petroleum Institute API RP540 for illumination levels of well pads and process area. Luminaire factors and uniformity ratios shall be per Illuminating Engineering Society of North America (IESNA) guidelines. General outdoor lighting shall be controllable by the DCS system.

5.3.4.2.2 In general, interior lighting circuits shall be switched from lighting panels. The use of local switches shall be kept to a minimum consistent with energy conservation techniques. Local switches shall be used in the case of offices and hallways.

5.3.4.2.3 Branch circuits using a common neutral conductor shall be arranged for minimum neutral current.

5.3.4.3 **Lighting Fixtures**

Lighting fixtures shall have the following requirements:

- In general, Light Emitting Diode (LED) lighting shall be used throughout the SPR.
- Flood and area lighting fixtures will be of the enclosed and gasketed vapor tight type.
- Incandescent-type fixtures may be considered for areas requiring low levels of illumination.
- Fluorescent lighting with high efficiency T8 lamps and electronic ballast is preferred for office areas.

- Power-over-Ethernet LED lighting meeting requirements of Chapter 15 should be considered for economic viability.

- Lighting directly over or near rotating equipment shall be designed to eliminate stroboscopic effects.

- Energy conservation shall be the major consideration in choosing the location, type of fixture and wattage.

- Fixtures shall be rated and labeled for operation within the hazardous area class of which they are installed.

- All fixtures located in process areas and at well pads shall be rated to operate at a minimum in Class 1, Div. 2 areas.

5.3.4.4 Lighting Levels

- Process Areas (HPPP, HEX, meter skid, etc.) – 5.0 FC at ground level

- Parking Areas – 0.1 FC at ground level

- General Operations and Maintenance Areas – 5.0 FC at ground level

- Roadway Lighting – 0.2 FC at ground level

- Cavern Pads – 1.0 FC at ground level

- Security lighting – See Chapter 13 of this document for requirements

For infrequently used roads, no roadway lighting is recommended.

5.3.5 CATHODIC PROTECTION

Cathodic protection shall be provided in accordance with National Association of Corrosion Engineers NACE requirements for all buried ferrous metals as required to insure the design life of the site. Test stations and rectifier control panels shall be located near roads or other locations that are accessible to operating personnel. Metals shall be coated to minimize cathodic protection requirements. A corrosion control survey shall be conducted to determine the type (impressed current or sacrificial anode) and requirements of the cathodic protection system to be used.

Cathodic protection systems shall be designed in accordance with site-specific requirements and shall be predicated on the results of a thorough soil resistivity survey.

Standard drawings and specifications shall be developed by the Architect-Engineer (A-E) for installation of the cathodic protection system.

Buried pipelines to be cathodically protected shall have test points for determining effectiveness of the cathodic protection system.

5.3.6 GROUNDING

A complete electrical grounding system composed of driven ground rods, cable loop (counterpoise system), and connections shall be provided. Motors, field-mounted push-button stations, panel-boards, dry-type transformers, and receptacles shall be grounded by the use of a green coded TW insulated copper conductor, run in conduit with power and control wiring. Equipment ground shall be provided for all electrical equipment per NEC requirements. The grounding system for outdoor structures such as cable trays and supports shall be designed to provide an adequate path for the lightning strikes to reach earth quickly and dissipate the voltage surge. Fences shall be grounded in accordance with Section 9E of the National Electrical Safety Code, ANSI C-2.

5.3.7 MOTOR CONTROL CENTERS

Motor Control Centers (MCCs) shall be provided to control and protect 480-volt motors. MCC’s serving essential loads shall be double-ended and shall be served by the 5KV loop where practicable. Essential loads are drawdown or fill related loads which consists of all process related equipment essential for meeting the SPR's mission.

Otherwise, critical loads shall be served from single-ended MCCs via automatic transfer switch(s) with diesel-generator backup to normal commercial power source. Critical loads are those energized during a utility power outage, as defined in Section 5.3.3

5.3.8 INTERIOR ELECTRICAL SYSTEMS

Interior electrical systems shall be in accordance with system performance criteria. Wiring methods shall generally consist of insulated conductors in rigid galvanized steel or electrical metallic tubing. Conduit shall not be installed horizontally in slabs-on-grade, and conduits under slab-on-grade shall be suitably protected from corrosion.

5.3.9 LIGHTNING PROTECTION

Lightning protection shall be provided in accordance with NFPA 780 for all Government-owned control buildings, administrative buildings, warehouses, maintenance shops, laboratories, flammable liquid storage buildings, vehicle storage buildings, emergency generators, motor control centers and field instrumentation buildings. For electrical substations, IEEE Standard 998 shall apply.

5.3.10 MOTORS

The following requirements shall apply to applications of electric motors.

5.3.10.1 Single-phase motors shall be limited to 0.5 hp or less. Motors 250-hp and larger shall be operated from medium voltage sources (except for fire protection equipment, which shall conform to Chapter 12). In general, larger motors installed outdoors shall be equipped with enclosures rated TEFC or TEAAC, and with stainless steel termination boxes. Power factor correction capacitors shall be connected to the large medium voltage motors. Motors installed in Class I Division 1 areas shall be housed in explosion proof enclosures.

5.3.10.2 Motors for critical applications shall be three-phase regardless of size.

5.3.10.3 All motor-operated valve actuators shall be of a standard integral control type equipped with phase discriminators.

5.3.10.4 **Motor Protection**

5.3.10.4.1 All three-phase motors below 600 volts shall be protected against overloads by thermal relays in each of the three phases or with solid state overload relays.

5.3.10.4.2 Induction motors 500 hp and larger shall be in accordance with API 541.

5.3.10.4.3 For large motors, generally 1500 hp and above, the following shall be provided:

- Forced feed lubrication systems shall match the driven equipment.
- Motor protection in the form of a solid state multifunction relay that shall provide differential protection and current transformers installed at the motor terminals, overcurrent protection, overload protection connected to resistance temperature detectors imbedded in the motor winding (device 49), for alarm and shutdown, and instantaneous overcurrent ground fault protection. Relay shall have hand reset lockout feature.
- Current-limiting power fuses.
- Excess vibration protection.

- Lightning surge protection shall be provided for motors of 300 HP and greater.

5.3.11 SYSTEM PROTECTION AND REGULATION

5.3.11.1 Protective relays or direct acting trips shall be provided.

5.3.11.2 A selective system shall be furnished insofar as practical. Relays and protective devices shall be selected and coordinated to provide a system which permits the circuit interrupting device nearest to a fault to operate first. Differential protective relaying shall be used on large substation transformers, circuit breakers, and substation bus.

5.3.11.3 A comprehensive coordination study shall be made to validate the capabilities of the protective devices. This study shall be the basis for the coordination and settings required for the various protective devices.

5.3.11.4 Overvoltage protection shall be provided for major components of the power system by use of surge arrestors and where required, surge capacitors.

5.3.12 WELDING AND CONVENIENCE RECEPTACLES

5.3.12.1 Basis of Design

5.3.12.1.1 When specified, welding receptacles shall be furnished on the basis of reaching any point within the unit where welding will be performed, assuming the use of 100-ft extension cords.

5.3.12.1.2 Welding receptacles shall be arranged in groups of not more than two outlets per each welding circuit. The size of the welding power supply feeder shall be based upon the following total continuous load:

One Welding Receptacle . . . . 35 KVA

Two Welding Receptacles . . . . 55 KVA

5.3.12.1.3 In enclosed areas convenience outlets shall be provided on the basis of adequate plant coverage assuming the use of 50-ft extension cords. In operating offsite areas convenience outlets shall be installed on the basis of adequate coverage using 100-ft extension cords.

5.3.12.1.4 Convenience receptacles shall be arranged in groups of not more than six for each lighting panel branch circuit. Receptacles in washrooms and outdoors shall contain ground fault circuit interrupters.

5.3.12.1.5 In office and control rooms, receptacle outlets shall be provided along the walls placed and spaced no more than 12 feet apart, with a minimum of 2 receptacles per room, in accordance with NEC.

5.3.12.2 **<u>Receptacle Types</u>**

5.3.12.2.1 Welding receptacles shall be rated 60 amps, 480 volts, three wire, four-pole. Welding receptacles located adjacent to hazardous areas shall be the explosion-proof circuit opening type. In non-hazardous locations, the welding receptacle shall be a weather-resistant type. Where both types of welding receptacles are provided, the selection shall be such that common plugs may be used with either receptacle.

5.3.12.2.2 If convenience receptacles are necessary for Division 1 and 2 locations, they shall be explosion-proof interlocked receptacle-switch combination, 20 amps, 120 volts, two-wire, three-pole type, and of the type providing for connection in accordance with NEC, Article 501.

5.3.13 RAW WATER INTAKE STRUCTURES (RWIS)

5.3.13.1 Motor Control Centers, Motors, and Transformers

5.3.13.1.1 Motors shall be Totally Enclosed Fan Cooled (TEFC) or Totally Enclosed Air to Air Cooled (TEAAC). Motors and transformers shall be equipped with 316 stainless termination boxes. Distribution transformers installed outdoors shall have stainless steel housing.

5.3.13.1.2 Transformers shall be mounted on solid pad foundations at least six inches above the deck or grade. Oil filled transformers shall have an oil containment system for accidental oil spills and shall be installed in accordance with FM guidelines.

5.3.13.2 Enclosures

5.3.13.2.1 Use 316 stainless steel or fiberglass junction and terminal boxes with drains installed in the bottom of the boxes.

CHAPTER 6

SUPPORT FACILITIES

6.1 PURPOSE

The requirements in this chapter pertain to the design, preparation of plans, and specifications for the support facilities and structures including tanks and helipads for the Strategic Petroleum Reserve (SPR) sites. It is desirable for newly designed facilities and structures to be compatible with their environment and to fulfill functional needs at a reasonable cost consistent with those objectives.

6.2 REQUIREMENTS - ARCHITECTURAL

6.2.1 DESIGN

All facility planning shall employ economical and completely functional architectural and engineering design with particular attention given to the selection of interior and exterior finishes and to type and extent of the services and equipment provided.

6.2.1.1 INTERIOR FINISHES

In selecting finishes, special consideration shall be given to preventing moisture and mold growth inside buildings. Specifically, vinyl wall coverings are prohibited as they can trap moisture which promotes mold growth.

6.2.2 SPACE

Space allowances shall meet the programmatic requirements for each support facility. A detailed engineering-economic analysis shall be made to determine the amount of space provided in each facility. Where user's space criteria are not available, accepted design and experience factors shall be used to determine space allocations for the various component functions of the buildings.

6.2.3 OCCUPANCY REQUIREMENTS

Personnel occupancy for the facility or its components, if not furnished by the user, shall be determined by the designer. The final occupancy requirements shall be justified in the design analysis in terms of male and female, permanent and transient, shift, working hours, and type of work.

6.2.4 COOL ROOF REQUIREMENTS

6.2.4.1 Roofs must be designed and installed with a minimum three-year-aged solar reflectance of 0.55 and a minimum three-year-aged thermal emittance of 0.75, or a minimum three-year-aged solar reflectance index (SRI) of 64 as determined by a laboratory accredited in accordance with the Cool Roof Rating Council (CRRC) product rating program. Materials shall be labeled and certified by the manufacturer.

6.2.4.2 New roof systems must achieve minimum R-value of R-30, including exterior roof coating and roof insulation. Thermal resistance is cumulative.

Roof deck assemblies with continuous insulation entirely above deck shall have minimum R-values of R-17. Insulation in metal building roofs shall have R-value of R-7 + R-7 with thermal spacer block of minimum R-3.5 between purlins and metal roof panels. Non-air-conditioned buildings must have roof ventilation or roof insulation with minimum R-value of R-13. All other roofs shall have insulation with minimum R-value of R-17.

Repairs of roofs must achieve a minimum value of R-30 where economically feasible.

6.3 REQUIREMENTS - STRUCTURAL

Structural designs shall utilize material efficiently, provide maximum usable space, minimize the use of special equipment, and be constructed by conventional methods. Consideration shall be given to future uses of the structure, possibilities of alterations, and maintenance costs.

6.3.1 STRUCTURAL MATERIALS

The basis of design and allowable unit stresses for various structural materials shall be in accordance with the latest issue of the codes and standards referenced in Appendix A.

When designing for seismic loadings, the provisions in the 6ASCE/SEI-7 regarding design considerations and allowable unit stresses shall govern.

6.3.2 BUILDINGS AND OTHER STRUCTURES DESIGN LOADS

Loadings used in structural design shall comply with Chapter 2, American Society of Civil Engineers (ASCE) 7, unless otherwise specified. All Design codes and assumptions shall be listed Structure Design Load documents such as the main drawing, notes drawing, plan view, etc.

6.3.2.1 **Dead Loads**. Dead loads include the weight of all permanent construction, including partitions, and building services and utilities which are fixed in position, such as plumbing lines and fixtures, electrical feeders, and heating, ventilating, and air-conditioning systems. Loads shall be accurately computed. Assumed dead loads for structural members shall be modified in the final design if the variation from the initial design assumption is appreciable.

6.3.2.2 **Live Loads**. Floor and roof loads recommended in ASCE 7, shall be considered as minimum requirements and shall be increased appropriately for local conditions (such as historical records showing higher winds experienced at the site).

Design documents shall show structural material strength, live loads, and lateral forces used in the design of all structures, buildings, supports and additions.

6.3.2.3 **Wind Loads**. All SPR structures and facilities shall be designed to sustain the maximum design wind loads as recommended in ASCE 7. Wind loads shall be calculated in accordance with ASCE 7 using the appropriate wind velocity and building or facility classification per Chapter 2.

Note: Vendor wind load table will be in in "Fastest Mile" coefficients instead of "3 Second Gust" as used by the latest building code. When comparing the vendor values to the building code, it will appear that the value of the vendor data is not strong enough.

6.3.2.4 **Earthquake Loads**. Earthquake loads shall be in accordance with the applicable section of ASCE/SEI-7. In the application of seismic data, the earthquake history of the locality in question shall be reviewed and historical data shall be examined in order to determine the probable earthquake risk. Refer to ASCE-7 for earthquake loads on structure types.

6.3.2.5 **Flood Loads.** Flood loads shall be in accordance with ASCE 24 Flood Resistant Design and Construction (ASCE/SEI 24). This standard provides minimum requirements for flood-resistant design and construction of structures located in flood hazard areas.

6.3.3 STRUCTURAL SYSTEMS

6.3.3.1 Framing

6.3.3.1.1 In general, buildings shall be framed structurally to permit simple form work, fabrication, and construction procedures. Appreciable savings are often possible through continuity in framing design; rational use of ultimate strength design and other up-to-date design and construction methods; use of the improved reinforcing bars and structural steels; and the appropriate use of high strength bolts instead of welding, rivets, or turned bolts.

6.3.3.1.2 Lightweight materials for floors, walls, partitions, and other building components shall be utilized where consistent with programmatic design assumptions and economy and with fire protection requirements.

6.3.3.2 **Control Joints**. When poured concrete or masonry walls are used, adequate control joints and expansion joints shall be provided. In long walls, design and location for control joints shall receive careful study in order to confine the effects of accumulated expansion and contraction. In addition, necessary bond beams and anchors to structural framing shall be provided for masonry units. Manufacturers' research data and recommendations shall be investigated in order to realize optimum performance of the various materials.

6.3.3.3 **Access Platforms**. Access platforms shall be installed where none exist to provide a proper standing working surface to access valve hand wheels, levers, instruments, gauges, controls, lubrication points, for tool use or safe access to other equipment. Access platforms shall be provided in the following situations:

6.3.3.3.1 where the vertical distance between the existing working surface and the centerline of the hand operator, the furthest control item whether it be a valve handle, actuator manual gear handle, or an actuator push button (or other similar equipment access) should not exceeds 4 feet 6 inches;

6.3.3.3.2 where the vertical distance between the existing working surface and the centerline of the hand operator the furthest control item whether it be a valve handle, actuator manual gear handle, or an actuator push button (or other similar equipment access) should not exceed 4 feet 3 inches;

6.3.3.3.3 where the distance between the front face of the hand operator (or other similar equipment access) and the toe of the operating personnel exceeds 1 foot 6 inches;

6.3.3.3.4 and where the frequency of access to a particular location as necessitated by the operation or maintenance of a single piece of equipment, or combination of pieces of equipment from the same location is once a month or more frequent.

The following design criteria shall be used for the design of the access platforms:

6.3.3.3.5 75 PSF live load for maintenance work; 26 PSF wind load on its vertical projection; 30 PSF uniform live load for access only

6.3.3.3.6 Stairway landings shall be no less than the width of the stairway and a minimum of 3 feet in width measured in the direction of travel; stair riser height shall not be less than 7 inches nor more than 9 inches.

6.3.3.3.7 In any flight of stairs, riser height shall remain constant; platforms, stairs, etc., shall be designed and proved to safely support four times the maximum intended load;

6.3.3.3.8 Scaffold foundations shall be adequate to support the maximum intended load and be secured from undesired movement.

6.3.3.4 **Site Lighting Poles**. The SPR standard for new and replacement light poles is galvanized steel construction. Based on the specific application, two styles of metal poles are allowable. (1) Folding for areas inaccessible by man lift and (2) rigid, which has a lower capital cost, but requires a man lift for light fixture maintenance. Only winches supplied by the pole manufacturer can be used to lower and raise site lighting poles.

6.3.4 SUBSURFACE INVESTIGATIONS

For all permanent structures, subsurface conditions shall be investigated by borings, test-pits, or other methods which will adequately disclose soil and groundwater conditions. Existing exploratory data shall be used when available. Caution shall be exercised in determining the number and depth of borings required.

In earthquake areas, appropriate geological investigations shall be made to determine the contribution of the foundation (subsurface) to the earthquake loads imposed on the structure. All surface investigations shall include, but are not limited to, a recommendation of foundation type, allowable soil bearing design capacity, and the possible effects of seismic activity on the soil mass. A settlement analysis under differential design loads shall be required where previous on-site data are not available.

6.4 REQUIREMENTS – MECHANICAL SYSTEMS

These criteria shall be applied in the planning and design of mechanical components of facilities. Included are heating, ventilating, and air conditioning systems for general service and allied facilities; and water and sanitary systems.

6.4.1 SYSTEMS

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

6.4.1.1 **Installed Capacities**. The initial installed heating, ventilating, and air conditioning system capacity for buildings designed for future growth shall be limited to 120 percent of peak design load unless additional capacity is required for operational reliability. For most buildings, the installed system capacity should be equal to the system peak design load.

6.4.2 HEATING, MECHANICAL VENTILATION AND AIR CONDITIONING SYSTEMS DESIGN CONDITIONS

Installation of Heating, Mechanical Ventilation and Air-Conditioning (HVAC) systems using regulated chlorofluorocarbons (CFCs) is unacceptable. Energy Star rated equipment shall be used to the maximum extent feasible.

6.4.2.1 **Design Basis**. General design guidance and load estimating procedures shall be based on data in the ASHRAE Handbooks . Both peak and partial (i.e., 75 percent, 50 percent, 25 percent) load calculations shall be prepared in order to analyze system operation and to determine proper equipment performance during these various operating modes.

6.4.2.2 **General Laboratory Ventilation**. The ventilation systems in laboratories shall conform to the OSHA Regulations 29 CFR 1910 Subpart Z, 1910.1450, Toxic and Hazardous Substances, Occupational exposure to hazardous chemicals in laboratories.

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

6.4.2.2.2 **Heating**. The minimum inside design temperature for winter personnel comfort shall be 72°F db unless otherwise indicated. Lower design temperatures may be appropriate for the particular application. The following applications indicate acceptable temperatures.

Space	Fdb
Storage (occupied)	55°
Warehouses	55°
Kitchens	60°
Shops (high work activity)	65°
Toilets	70°
Change Rooms (heating only when occupied)	75°

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

6.4.2.3 **Outside Design Temperatures**. Design temperatures shall be as shown below for the particular application as determined from the tabulated weather data in the ASHRAE Handbook. Where data for a particular location are not listed, design conditions shall be estimated from data available at nearby weather stations or by interpolation between stations, taking into account elevations and other local conditions affecting design data.

Application	Winter	Summer
Industrial, process, laboratory and other non-personnel comfort systems	99%db	1%db and mean coincident wb*
Personnel comfort systems	99%db	2-1/2%db and mean coincident wb*

*Mean wb temperature coincident to the area of the design

6.4.2.4 **Personnel Ventilation Air**

6.4.2.4.1 The outside air ventilation rate shall be at least 5 cfm/person in conditioned offices and other occupied spaces, as recommended in ASHRAE Standard 62.1, "Ventilation for Acceptable Indoor Air Quality." Additional outside air may be required for central air handling systems to balance the system exhaust air rate, in order to maintain a building or space under a slight positive pressure (0.05-inch water static pressure).

6.4.2.5 **Equipment**. Refrigeration equipment and associated air handling equipment design, fabrication, installation, and testing shall conform to applicable standards.

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

6.4.2.7 **Operating Temperatures**. The temperatures to be used for the building energy consumption analysis shall conform to the Federal Property Management Regulations (FPMR), 41CFR101, Sub-chapter D, Section 101-20.116, unless otherwise justified.

6.4.3 MECHANICAL VENTILATION

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

6.4.4 CONTROLS AND ZONING

6.4.4.1 The arrangement and number of temperature-controlled zones are normally established by fire separation area requirements, health and safety hazards, space operational requirements, load fluctuations due to occupancy, exposure, building size and configuration. Automatic temperature and humidity controls shall be installed as required. Electronic control systems (vs. pneumatic) shall be used on new or re-worked systems.

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

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

6.4.4.4 Automatic temperature control devices for personnel comfort should have a heating control range between 55^{o}F and 70^{o}F and a cooling (where required) control range between 75^{o}F and 85^{o}F. The automatic temperature control system shall not be capable of simultaneous heating and cooling.

6.4.4.5 Manually adjustable automatic control setback and/or shutdown devices shall be provided for all heating and cooling systems in order to reduce the energy consumption during non-occupied periods.

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

6.4.5 PLUMBING SYSTEMS

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

Adequate vent piping, sized to meet the minimum needs, is a requirement of a properly designed sanitary drainage system.

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

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

6.4.5.3 Water Supply and Distribution

6.4.5.3.1 Cold Water Service Connection. Wherever possible, service entrances shall be sized to provide sufficient flow at required pressure for all fixtures without the use of pumps. The sizing of service entrances shall be in accordance with applicable codes and standards, using the minimum pipe size practicable without excessive noise-producing velocities or wasteful pressure losses.

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

6.4.5.3.2 Domestic Hot Water Temperatures. Domestic hot water storage design temperature shall be limited to 110ºF. Cooking, process, laboratory, or other special requirements for water may be in excess of 110ºF. Lavatory fixtures shall use a single spray head type faucet that has a flow restrictor to provide approximately 0.25 to 0.50 gpm water flow. Utility rooms may have both hot and cold water for cleaning purposes.

6.4.5.3.3 **Hot Water Heating and Storage**. The total demand for domestic hot water may be estimated on the basis of fixture-units. Individual studies shall be made for other facilities with unusual or heavy demands. The selection of domestic hot water heaters shall be based upon an economic balance of the maximum daily demand, the maximum hourly demand, the first cost of equipment, operating costs, availability and cost of fuel, the quality of the water and the space required.

6.4.6 MECHANICAL SYSTEMS INSULATION

Insulation for ducts, piping, and heat-producing equipment shall be provided where resulting economies will offset the cost of the insulation within its life expectancy, or where required to prevent damage or unsatisfactory working conditions from heat or condensation. The insulation shall be selected to obtain maximum economy with minimum maintenance, repair, or replacement and comply with fire protection requirements of this document. In economic studies, the life expectancy of the insulation shall be assumed to be not over 20 years for laboratory and administrative type, 10 years for industrial process type applications. Insulation (coverings and linings) shall conform to the requirements of National Fire Protection Association (NFPA) 90A, "Air Conditioning and Ventilation Systems." The flame spread and smoke developed ratings shall be clearly labeled on the material to be specified, procured, and installed (See Chapter 12).

6.5 REQUIREMENTS - ABOVEGROUND CRUDE OIL STORAGE TANKS

6.5.1 GENERAL

Storage tank design shall conform to American Petroleum Institute (API) 650 or API 12F as determined appropriate by the design engineer for the size and intended service (Fire Protection per Chapter 12). Tanks shall be provided with connections, valves, gauging hatches, and internal roof drains. Tank mixers shall be provided on a case-by-case basis.

Tanks shall be diked to: (1) contain 110 percent of the shell capacity of the largest individual tank, OR (2) contain the shell capacity of the largest individual tank plus capacity to contain a 25-year, 24-hour rainfall, OR (3) designed to drain to a remote impoundment. Containment capacity shall be supported by the certifying engineer and based upon best engineering judgment.

At locations equipped with pipeline metering, and for sites where only one type of crude oil is being stored, the number of tanks required for filling is one. Heating and oil circulation systems shall be provided on residual and other heavy oils, particularly in low temperature locations, where experience dictates their requirement in order to successfully pump the heavier oils.

Crude oil shall be stored in tanks fitted with double deck floating roofs when capacity exceeds 20,000 bbl per tank. All tanks will be designed for worst-case sour crude.

6.5.2 SPECIFIC

6.5.2.1 **Construction**. Only floating roof tanks shall be used for crude oil storage exceeding 20,000 barrels capacity.

Flotation compartments shall be welded airtight. Flotation compartment manholes shall be provided with a liquid tight cover that is gasketed and held in place by bolting or other means suitable for hand operation. Covers shall be equipped with a welded vent pipe of nominal 1-inch diameter, extending 18 inches above the cover and terminating in a manner to prevent entry of rain. Details of floating roof tank design should be in accordance with API Standard 650 "Welded Steel Tanks for Oil Storage".

All SPR tanks, with fixed or floating tank roofs, shall be designed to provide structural integrity to protect against dry or fluid collapse or destruction from fire protection systems and tests.

Fixed roof tanks, where used, shall be designed with weak roof or weak shell to roof seams designed to fail preferentially to the tank shell in the event of fire or internal explosion.

6.5.2.2 **Arrangements**. The spacing between floating roof crude oil tanks shall be one half of the tank diameter. The spacing between fixed roof tanks shall be one tank diameter. Spacing between tanks need not exceed 200 feet.

Tanks shall be no closer to the dike or toe wall than one-half the tank-to-tank spacing.

Dikes around tanks should be suitable for potential hydraulic forces. Dikes shall comply with NFPA 30 requirements for access and egress. Dikes and toe walls shall be liquid tight. Impervious fill dikes shall be well compacted and at least three feet wide on top.

Diked areas shall be drained away from the tanks toward a sump, drain box, or other means of disposal a safe distance from the tank. Drains should discharge to a safe location through oil water separators. Drain lines shall be trapped. These lines should be provided with valves that are outside the dike and that are accessible under fire conditions. The valves shall be kept normally closed and shall be clearly marked.

Dikes shall not contain pumps or auxiliary equipment. Necessary piping should exit the dike directly, not passing through other tank dikes. Drainage shall be away from valves and flanges.

Dikes for floating roof tanks shall be arranged so that one or more tanks are contained within a single dike and each tank within the dike shall be separated by a toe wall. The toe wall shall be one foot lower than the dike wall, but in no case less than 18 inches high.

Where full impounding capacity is not practical at the tanks, the use of remote impounding basins is permitted. The following limitations apply:

- Tank spacing limits shall not be reduced.
- The impounding basin shall be capable of containing twice the capacity of the largest tank that can drain into it.
- The impounding basin shall be equipped with means to drain water from precipitation through lines equipped with closed valves and suitable oil water separators.
- The basin shall be no closer than 0.3 times the basin diameter or diagonal to flammable liquid tanks.
- The basin shall be no closer than 0.6 times the basin diameter or diagonal to facilities of noncombustible construction.
- The drain capacity from each subdivision within a dike shall be capable of removing liquid at a rate not less than that expected assuming a break in a bottom connection from the largest full tank or the maximum fill rate, whichever is greater, plus the fire protection water and foam demand.
- Channels within a dike shall be paved with asphalt or concrete or covered with smooth stone or compacted clay or similar material to prevent growth of vegetation which could restrict liquid flow.

- The slope of drainways shall be a minimum of two percent the first 50 feet, and one percent thereafter to reduce size. Design should assume they are flowing full.

6.5.2.3 **Tank Bottom**. For earth foundations, the tank bottom shall normally be coned upwards, the angle of slope to be as per foundation design, with a minimum of one inch in ten feet. Water and sludge drainage shall be from sumps located near the shell.

6.5.2.4 **Wind Loading**. All tanks and vessels shall be designed to be self-supporting. The design wind load shall be in accordance with this document, with consideration for ladders, platforms, overhead lines supported by the tank or vessel, plus any other loads affecting the ultimate stability of the tank or vessel.

6.5.2.5 **Tank Dimensions and Capacities**. Tanks shall conform to the standard diameters. Heights of tanks are not standardized, and the heights shown in API Standard 650 are for information purposes only. In selecting tank dimensions, the highest tank compatible with permissible ground loading and economic fabrication shall be chosen.

Primary tanks, over 20,000 bbl capacity, shall be drain-dry, open top, double-deck or flotation compartment floating roof, welded steel type. Surge tanks 20,000 bbl and smaller may be cone roof type with a weak roof to shell seam.

An approximation of the working capacity of tanks shall be calculated by assuming a negative capacity at the top of the tank of 1 foot 6 inches for floating roofs, and an ullage space in fixed roofs of 6 inches. For fixed roof tanks, the dead space at the bottom will extend to 6 inches above the suction branch. For floating roof tanks, the lowest position of the roof shall be 10 inches above the suction branch, i.e., with the bottom of the legs 6 inches above the base of the tank. If roof landing is permitted during normal operation, the lowest position shall be 6 inches above the suction branch.

The actual allowances shall depend on such factors as the position and size of outlet branches, the position and type of pump, rate of pumping and type of level instrumentation.

For slop tankage, such as light and heavy slop, recovered oil, tank ballast and washings: etc., the working capacity of each heated tank shall be based on a minimum dip of three feet above the heating coil.

In selecting the height of a tank, the tank base pressure shall not exceed the safe load-bearing capacity of the ground. In calculating the base pressure, the mass of the contents or the water capacity, whichever is the heavier, shall be used. Where rolling ladders are required, the height of the tank shall not exceed the tank diameter.

6.5.2.6 **Tank Shell Fittings**. The orientation of the roof and shell fittings shall be such that the installed equipment will work accurately and effectively. For example, the flow from a mixer shall not be hindered unduly by the heater locations. The dipping and level gauge tubes shall be located in the least disturbed areas and be readily accessible from the gauger's platform.

The recommendations of the supplier shall be followed for the installation of automatic liquid level and temperature measuring instruments on storage tanks.

Branches for mounting instruments and liquid level indicator tubes shall be in accordance with the instrument design and located to be accessible for maintenance.

The following checklist covers tank shell fittings which may be required, but the number, type, size, and location of fittings shall be specified to the tank fabricator for each tank.

6.5.2.6.1 Branches for Tank Contents

- Inlet (with internal extension for floating roof tanks as specified by tank manufacturer).
- Outlet (the inlet and outlet may be combined where advantageous).
- Gas blanket.
- Pump-out (to empty tank completely).
- Water draw-off.
- Jetting.
- Mixers.

6.5.2.6.2 Branches for Services and Maintenance

- Steam, with weld and internal extension.
- Condensate, with weld and internal extension.
- Foam for firefighting.
- 24-inch diameter shell manholes.
- Flush-type clean-out doors.
- Non-flush clean-out doors.

Note. The last two items are not normally fitted, but when they are required, the limitations imposed by the code on shell design in respect to large openings shall be observed.

6.5.2.6.3 <u>Branches for Instruments</u>

- Level alarms, critically high, high and low positions.
- Mixer cut-out float switches.
- Thermowells as required.

<u>Note</u>. For fuel oil and slop tanks, thermowells should be located approximately 2 feet 6 inches above the heating element. For other tanks the position shall be agreed upon with the designer.

6.5.2.6.4 <u>Brackets and Supports for</u>

- Mixer Support Stays.
- Stairway.
- Insulation.
- Pipes, e.g., for foam (dry risers) water sprays and gas blanket.
- Instrument piping and conduit.

6.5.2.7 **<u>Nozzle Details</u>**. To avoid generating a static charge by splashing, inlet nozzles (other than for foam) shall be positioned so that liquids are not introduced above the lowest working liquid level. Where a nozzle jet is required which can be used for filling purposes, a companion open-ended nozzle shall be fitted in the tank shell.

Special fittings are required for floating roofs, and as they are dependent on the type of roof, details shall be supplied by the roof manufacturer.

Tank nozzles shall not be over-stressed by loads resulting from connected equipment such as piping, valves, and mixers. Supports, anchors, flexible piping configurations and connections shall be provided as necessary.

When shell plates with openings require post-weld heat treatment, the nozzles shall be grouped in as few plates as possible in order to reduce costs. Welding may be carried out without post heat treatment (stress relief) within the limits permitted by the design code.

The axes of grouped nozzles shall be parallel with each other to facilitate the arrangement of the connecting pipework.

Except for elevated tanks, side connections having dished sumps shall be preferred for pumpout nozzles. Where bottom connects are essential on non-elevated tanks, precautions against damage to the connections by foundations settlement shall be taken.

The pumpout nozzle shall be located next to the main outlet nozzle so that the pumpout may be connected conveniently into the outlet piping downstream of the tank valve.

The pumpout nozzle shall be sized to suit the required pumpout rate and as a guide the following nominal nozzle sizes are suggested:

Tank diameter less than 60 ft	- 4 inches
Tanks 60 ft to 168 ft diameter	- 6 inches
Tank diameter greater than 168 ft diameter	- 8 to 10 inches

The pump-out nozzle shall be fitted with a separate 4-inch water draw-off connection as per API Standard 650, Table 3-18 and for tanks where uneven settlement of the foundation may occur (except for crude oil tanks), additional 4-inch nominal water draw-off nozzles with draw-off sumps, shall be provided as follows:

50 ft - 100 ft diameter	1 additional
Above 100 ft to 150 ft	2 additional
Over 150 ft	3 additional

Connecting pipework shall conform to the requirements of Chapter 4 without exceeding allowable stresses. Pipework shall be provided with the required flexibility to accommodate any differential settlement between the tank and the piping and for any thermal expansion of the piping. For large tanks particularly, the expansion of the shell and consequent tilting of the nozzle due to hydrostatic head can be significant.

Jets and/or mixers shall be installed for blending products or crude oils, ensuring that components are homogeneous and to prevent crude oil sludge deposition.

The nozzle provided for the mixer shall be sized to pass the propeller, with the propeller attached to the mixer.

6.5.2.8 **Fixed Roof Fittings**. Roof manholes 20 inches in diameter shall be provided; one for tanks 30 feet in diameter or less, and two for tanks over 30 feet in diameter.

6.5.2.8.1 **Vents and Relief Valves**. Vapor emission control devices shall comply with the appropriate environmental requirements without compromising the safety relief features of the task.

The number and size of vents provided shall be based on the venting capacity obtained from API Standard 2000 and shall be sufficient to prevent any accumulation of pressure or vacuum.

It shall be assumed for venting purposes that tanks designed for fixed roof, with roof-to-shell attachment, shall have the weak roof-to-shell attachment referred to in paragraph 1.3.1 of API Standard 2000. In addition to the oil movements in the design case, the venting capacity shall accommodate all tank transfers possible with the installed piping system, such as gravity feeding between tanks.

For fixed roof non-pressure tanks containing high flash point material, which is never heated above the flash point, free vents shall be provided. The free vents shall be fitted with screens of 4 x 4 mesh. If, however, the contents of a fixed-roof tank are liable to be heated above the flash point, pressure and vacuum valves shall be required.

One 6-inch hatch for dipping and sampling shall be provided. A manufacturer's combined dip and vent fitting may be provided. For low pressure type 8-1/2-inch water gauge gas blanketed tanks, an approved type of "slot dipping device" shall be used to permit dipping and sampling without venting gas to the atmosphere.

In tanks where liquid interfaces must be determined, sample points operable from ground level shall be installed at appropriate vertical intervals. The points shall discharge into a common drain, and, where necessary, the system is to be heat traced to prevent plugging.

6.5.2.8.2 **Control Instrumentation for Tankage**. For fixed roof tanks the following control instrumentation shall be provided. A ground reading tank gauge shall be installed on all storage tanks. A ground reading tank gauge, with a solid-state electronic transmitter in an explosion proof enclosure for remote readout of tank levels in the control room shall be installed on all major storage tanks. High level and critically high (remote) alarms are required.

6.5.2.9 Floating Roof Fittings

6.5.2.9.1 **Manholes**. Deck manholes 24 inches in diameter shall be provided for fixed roofs, and 24-inch diameter through manholes for double deck roofs. One manhole shall be fitted to roofs up to 30 feet in diameter and two for larger roofs. One 20-inch diameter manhole shall be provided for each flotation compartment.

6.5.2.9.2 **Vents**. The number of rim vents to be fitted to the roof shall be specified by the tank fabricator. Automatic bleeder vents on crude tanks shall be made of carbon steel. The tank fabricator is to be informed of the maximum flow rates into and out of the tank to allow him to determine the size and number of bleeder vents required, and also to size an appropriate vacuum breaker for emergency use when the floating roof has grounded and pumping has continued.

6.5.2.9.3 **Drains**. If recommended by the tank fabricator, emergency open-type drains may be fitted, to double-deck type roofs or to floating compartment roofs having more than 50 percent pontoon area. Drain plugs shall be provided for use when the tank is taken out of service.

6.5.2.10 **Stairways, Gangways, and Handrails**. This equipment shall comply with both the requirements of API Standards and those set forth below.

Stairways shall be spiral, radial, tangential or any combination of these types. Radial and tangential stairways shall be so designed that their support foundations are placed clear of the tank foundation. Supports shall be designed to allow for differential settlement between the tank and the support foundation.

6.5.2.10.1 **Gangways**. Tank gangways which extend from part of a tank to ground or to other structures shall be so supported as to permit free relative movement of the connected structure. The design of gangways between tanks shall make provision for differential tank settlement.

6.5.2.10.2 **Platforms**. Gauger's platforms are required for floating roof tanks, and unless otherwise specified, for fixed-roof tanks. The platforms shall be suitable for the installed instrumentation and equipment.

When a dip hatch, sample hatch or other fitting requiring operational access is located at the center of the roof, bar treads shall be provided between the gauger's platform and the center of the roof. In the case of a domed roof, if the slope exceeds 15 degrees, and/or if the roof is insulated, stair treads should be provided instead of bar treads. A single handrail to the center and a handrail all around the periphery of the tank shall be required in such cases.

Where wind girders on floating roof tanks are provided with a handrail, a stairway or platform, as appropriate, shall be provided between the wind girder and the tank stairway or gauger's platform.

6.5.2.10.3 **Handrails**. Roof edge handrails should extend 10 feet on both sides of the gauger's platform on fixed-roof tanks.

6.6 REQUIREMENTS - HELIPADS

6.6.1 GENERAL

Helipads shall be designed and constructed in accordance with Federal Aviation Authority (FAA) AC 150/5390-2C and 70-7640-1M. A notice of construction will be filed with the FAA in accordance with 14 CFR (Code of Federal Regulations) Part 157.

6.6.2 DESIGN

The following sections of AC 150/5390-2C shall be used in the design and construction of helipads:

Chapter 1 – Terminology (ALL)

Chapter 2 – General Aviation Heliports (Sections 200-206, 209.a, 209.b, 209.f, 209.g, 210.a, 210.c, 211)

Chapter 8 – Heliport Gradient and Pavement Design (ALL)

Helipads shall be designed and constructed in accordance with Federal Aviation Authority (FAA) AC 150/5390-2C and 70-7640-1M. A notice of construction will be filed with the FAA in accordance with 14 CFR (Code of Federal Regulations) Part 157.

CHAPTER 7

MARINE TERMINAL COMPLEX

7.1 PURPOSE

This chapter establishes design requirements to be implemented for Strategic Petroleum Reserve (SPR) Marine Terminal Complexes.

7.2 DESIGN REQUIREMENTS

The designer shall assure compatibility of the newly designed systems with those of any existing or proposed connecting ports and terminals. Pumping rates for fill and withdrawal, oil accountability, hydraulic surge, surge tankage, communications, etc., shall be analyzed for compatibility among connecting SPR sites and the associated ports and terminals.

The design of the Marine Terminal Complex shall comply with Title 33, Part 154, Code of Federal Regulations, "Facilities Transferring Oil or Hazardous Material in Bulk" and shall ensure performance criteria as set forth in the SPR Performance Criteria Level II are met. Piping shall be installed in accordance with American National Standards Institute/American Society of Mechanical Engineers (ASME) B31.3.

7.3 CONSTRUCTION REQUIREMENTS

Construction of the dock structure shall be in accordance with National Fire Protection Association (NFPA) 307, "Standard for the Construction and Fire Protection of Marine Terminals, Piers and Wharves."

CHAPTER 8

LIQUID PIPELINES

8.1 PURPOSE

This chapter covers the design requirements for materials, fabrication, installation and testing of cross-country pipelines, located outside site/pipeline boundary.

8.2 DESIGN REQUIREMENTS

The design requirements of Strategic Petroleum Reserve (SPR) pipelines shall be in accordance with the codes specified for the service as shown in Table 8-1. Pressure, temperature, dynamic effects, thermal expansion allowable stress, pressure design of components, and intersection requirements are also found in Table 8-1 references.

8.2.1 CURVED SEGMENTS OF PIPE

Changes in direction shall be in accordance with the codes and standards for the applicable service as shown in Table 8-1, except that the minimum radius for free stress design of river, canal or stream crossings for all services shall be as follows:

$$R = \frac{1.25D \times 10^6}{0.3\ SMYS}$$

where: R = minimum radius, feet
D = pipe outside diameter, inches
SMYS = specified minimum yield strength of the pipe material

8.2.2 CLOSURES, FLANGES, AND REDUCERS

Closure heads shall be designed in accordance with the requirements of the latest American Society of Mechanical Engineers (ASME) Section VIII and shall have pressure and temperature ratings based on the same stress values as were used in establishing the pressure limitations for the adjoining pipe of the same or equivalent steel.

Flanges shall conform to code requirements for the pressure and temperature ratings established in these standards. The bore of welding neck flanges subject to scraper passage shall correspond to the inside diameter of the pipe with which they are to be used.

Reduced outlet weld fittings shall conform to the requirements for the pressure and temperature ratings specified by referenced standards.

8.2.3 HYDRAULIC CALCULATIONS

The following are suggested standard equations to be used.

8.2.3.1 Pipeline Flow Pressure Drop

Flow pressure drop through piping for all fluids shall be calculated using recognized formulas such as Darcy equation, with the friction factor obtained from the Moody charts, or calculated from formulas such as the Colebrook and White or Sachem equations.

8.2.3.2 Hydraulic Surge Pressure

Sudden blockage of a flowing fluid in a pipeline causes a hydraulic surge pressure wave to develop. The surge pressure added to the steady state pressure shall not exceed that set forth in ASME B31.4.

All large piping systems shall be reviewed for potential surge problems. Systems cited as possible problems shall be mathematically analyzed using recognized equations.

For velocity (celerity) of pressure waves,

$$v = 4720/(1 + \frac{Kd}{Et})^{0.5}$$

where:
K = fluid bulk modulus, psi
d = pipe ID, inches
E = pipe modulus of elasticity (steel = 30,000,000 psi)
t = pipe w.t., inches

(Standard Handbook of Engineering Calculations, Hicks, 1972, p. 3 – 383)

K = 315,000 lbs./in^2 for water, sp. gr. 1.0 @ 60°F
= 200,000 lbs./in^2 for oil, sp. gr. 0.8 @ 60°F
= 345,000 lbs./in^2 for brine, sp. gr. 1.19 @ 60°F

The designer shall provide hydraulic transient analyses of all fluid piping systems. In general, the transient analysis provides a time plot of pressure at any point in the pipeline system. Some of the boundary conditions that shall be investigated are pump failure, pump start-up, specified flow versus time for control valves, specified valve motion versus time, and specified flow in pipeline section (node) versus time at the investigated pipe section (node).

8.2.3.3 <u>Velocity Parameters</u>

8.2.3.3.1 **Pipeline.** Design velocity for steel pipelines shall be in the 6 to 9 feet per second range based on the most economic design. Figure 8-3 indicates the preferred design velocities against pipe diameter to avoid settling entrained particulates for steel brine and raw water lines, where under-deposit corrosion/erosion can be a problem.

8.2.3.3.2 **Secondary Piping.** All piping manifold systems shall be limited to the fluid's erosion velocity and designed per references in Appendix A. Secondary piping shall include all pump manifold and other ancillary piping systems. Erosion velocity calculations shall be per American Petroleum Institute (API)-RP-14E, Paragraph 2.5a.

8.2.3.4 Characteristics of the Fluids

Physical properties of the specific fluids to be pumped and/or stored at any given site in the SPR shall be known before hydraulic calculations can be performed. Where a range of crude oils, brines and fresh water are to be needed, design shall be predicted on "worst case" conditions. For pumps in crude oil service this means that the pump must be designed to pump the lightest oil allowed per Level 1 Criteria, Appendix C, and the driver for the pump must be designed for the heaviest oil allowed per Level 1 Criteria, Appendix C. For pumps used for filling caverns the pumping system must be designed to fill full caverns at rates necessary to support the fill rate specified in Level 1 Criteria Appendix A. The performance of this design shall then be checked for other conditions to ensure performance objectives will be met regardless of the fluids in the system.

8.2.4 CORROSION

The effects of external corrosion and internal corrosion and the erosion-corrosion mechanism will be a major consideration in all piping and pipeline designs.

8.2.4.1 External and internal corrosion control shall be as outlined in Chapter VIII of ANSI/ASME B31.4, 49 Code of Federal Regulations (CFR) 195, and in other locations of Chapter 8.

8.2.4.2 In addition to the above, the following design considerations will be accomplished: (a) determine biological contaminants, particulate content, and erosion-corrosion characteristics of the process fluids, (b) calculate the "worst case" corrosion fouling and erosion-corrosion rates for the process fluids based on fluid characteristics and design flow rates.

8.2.4.3 Modify fluid design velocities to prevent internal piping loss during the site (system) life cycle and/or increase pipe wall thickness or line/coat pipeline interior as necessary to prevent failure. In no case shall brine or raw water pipeline velocities be designed below the deposition velocity shown on Figure 8-3 nor shall the upper design flow rate of cement-lined pipe exceed 9 feet per second.

8.2.4.4 In potentially severe cases of biological fouling, corrosion or erosion-corrosion, consider additional methods of control such as inhibitors, dehydration, degeneration, oxygen scavenging, corrosion resistant alloys, in addition to internal pipe coating.

Risk and cost analyses shall be conducted to estimate potential damage, and the costs to incorporate one or more of the methods listed in the previous paragraph to mitigate the damage.

Where corrosion coupons are installed, access platforms shall be provided for safe use of coupon retrieval tools.

SPR brine transportation pipelines shall be internally lined with a cement mortar mix, following the requirements of API-RP10E. For straight pipe sections in brine service, use a centrifugally applied internal lining consisting of a Portland cement fly ash mortar mix. For bends, fittings, and field repairs in same service, a hand-troweled internal lining consisting of calcium aluminate cement-sand mix formulation shall be used. High Density Polyethylene (HDPE) is also a viable material choice, when size and pressure requirements allow it.

8.2.4.5 Flanged spools, ells, tees, and coupons should be provided at selected points in piping systems to permit periodic internal inspection of piping segments. Inspection ports shall be provided for water service lines.

8.2.4.6 All pipeline fittings of internally cement-lined pipelines shall be internally reinforced with an expanded metal reinforcement per API-RP10E to prevent corrosion/erosion.

8.2.5 PIPE STRESS

Stress calculations for piping systems shall be performed as outlined in ASME B31.4, Section 419 in accordance with the applicable codes and specifications listed in Table 8-1.

8.2.6 PIPE SUPPORTS

Supports shall be designed to support the pipe without causing excessive local stresses in the pipe and without imposing excessive axial or lateral functions forces that might prevent the desired freedom of movement. Supports also shall be designed to prevent corrosion between the pipe and supports.

8.3 SPECIFIC REQUIREMENTS

Standard specifications shall be established for the pipe and piping components used on SPR pipelines. The following are guidelines to be used for pipeline components.

8.3.1 PIPING COMPONENTS

8.3.1.1 Pipe

Only new pipe shall be used. The pipe shall be in accordance with API specifications, see Appendix A. Pipe shall not exceed the yield strength requirements of API 5LX-60 and the carbon equivalent shall not exceed 0.45 (calculated per MSS-SP-75). No telescoping of pipe shall be allowed. Line pipe shall be seamless, submerged arc welded, electric resistance welded, or high-frequency welded. Only longitudinal welding shall be acceptable for pipelines in hydrocarbon service; Helical pipe (SAWH) may be used in Raw Water and Brine Service in straight pipe segments only. Furnace butt-weld line pipe shall not be permitted. Mill certifications for all piping shall be required. Documentation shall include as a minimum information on lot, batch number, material, date of manufacture, in-plant testing (including toughness), and X-rays.

8.3.1.2 Fittings

Fitting shall be butt welded pipeline fittings that are suitable for welding to the pipe. The yield strength of the fittings should match the yield strength of the pipe but in no case should the fitting exceed MSS-SP-75, WPHY-60 requirements. Fitting carbon equivalent should not exceed 0.45 calculated per MSS-SP-75.

Where passage of scrapers, spheres, or internal inspection equipment is required, tees shall be equipped with scraper bars on the side outlet and ells and shall have a minimum radius sufficient to allow passage of this equipment.

Welded branch connections (tees and full encirclement saddles) shall be designed in accordance with the applicable codes and specifications as listed in Table 8-1. Connections to piping 2 inches and less in diameter may be made with extra heavy couplings, weld-o-lets and sock-o-lets. Any pressure connection to a mainline shall be a minimum of 2 inches. Pressure, temperature or other similar taps less than 2 inches in diameter shall be placed off the mainline at the scraper traps, and at mainline valve by-pass piping.

Fittings shall be internally coated on brine/raw water lines to preclude erosion/corrosion.

8.3.1.3 Bolting

All bolting shall be A193 Gr. B7 studs and A194 Gr. 2H heavy hex head nuts. Bolts and nuts shall be fluorocarbon coated.

8.3.1.4 Flanges

All flanges shall be raised face (RF) weld neck (WN). Ring joint (RTJ) flanges may be used to connect to pumps and other specialized equipment. They shall be weld neck design. Flanges smaller than 12 inches shall comply with ASME B16.5. Flanges 12 inches or larger shall comply with Manufacturers Standardization Society (MSS)-SP-44.

Flanges which will be welded to line pipe shall be specified as being compatible for welding to the particular grade considered. Flanges shall not exceed yield strength requirements of MSS-SP-44, Grade F-60 nor exceed 0.45 carbon equivalent.

8.3.1.5 End Transition and Preparation

End preparation of pipe, fittings, valves, and flanges shall be standard as specified in Table 8-1. Bevels shall be 30° plus 5° minus 0°.

Where different wall thicknesses are used the transition between ends shall be accomplished in accordance with ASME B31.4 and ASME B31.11 or by means of a transition piece. Transition pieces shall be not less than one-half pipe diameter in length. Transition material shall equal the highest minimum yield strength of the adjacent pipe. One end shall be tapered (1 on 4) to meet the wall thickness of thinner pipe.

8.3.1.6 Transition Between High- and Low-Pressure Zones

The low-pressure transition zones shall be so designed that a single point failure (valve failure to close, etc.) shall not introduce pressures higher than the system is designed.

8.3.2 GENERAL DESIGN

Facilities shall be provided on all lines to enable them to be pigged before commissioning and during operation. Adequate means of isolation shall be provided to enable all sections of lines and associated piping to be hydrostatically tested. Pipeline design shall provide for and be fully compatible with installation of the standard SPR leak detection system. All pipeline designed for pigging shall include provisions to launch, receive, or handle intelligent scraper devices.

Double block and bleed valves shall be provided at each end of all lines (except at the diffuser end of brine lines), at all connections to pipelines and where necessary, for safety or maintenance reasons, to isolate long lines into sections. Thermal relief valves shall be provided on each section of aboveground liquid fluid lines that could be isolated between block valves (or buried lines when necessary).

Vent and drain connections shall be provided where necessary for satisfactory commissioning and operation.

Insulating joints shall be provided where necessary in cathodically protected lines to isolate unprotected installations from protected installations.

8.3.2.1 Wall Thickness

Liquid lines shall be designed to operate in steady-state conditions at a maximum hoop stress in the pipe wall as determined by the applicable code.

The calculated effects of transient surge due to sudden closure of valves or stoppage of pumps, etc., should not increase the maximum hoop stress to more than 80 percent of the specified minimum yield strength of the pipe steel when operating at maximum pressures and flow rates.

In calculating minimum wall thickness consideration shall also be given to the effects of transient surge downstream of the initiating point. Pipeline wall thickness plus a 0.125-inch corrosion allowance shall be used to satisfy design conditions, subject to the pressure/temperature limitations given in the applicable code and specification listed in Table 8-1 and taking into account the minimum thickness required for satisfactory handling and construction. Consideration shall be given to increasing wall thickness at field bends. Road and water crossings shall utilize increased wall thickness in preference to casing.

Road and water crossings shall utilize increased wall thickness in preference to casing. Other low points, such as pipeline crossings, shall utilize increased wall thickness, especially for crude oil pipelines.

8.3.2.2 Materials

Materials of construction shall comply with applicable code requirements. Fully welded construction shall be used where possible. All welding shall comply with the applicable codes listed in Table 8-1, or the task package on cement-lined pipe.

Screwed joints shall be avoided if possible, their use shall be limited to those joints which will have to be disconnected during service. All removable connections 2-inches and larger shall be flanged.

Where hydrogen sulfide is present in the flowing fluid, particular attention shall be given to the selection of suitable materials to avoid problems due to stress corrosion or cracking.

8.3.3 VALVES

All pipeline valves shall conform to API 6D and be SPR standardized pipeline valves. All compact steel gate valves shall conform to API 602. All mainline isolating valves shall be full opening, weld end, through-conduit gate or ball valves. Valves to be installed off the mainline (not subject to scraper passage) may be reduced port. All mainline valves shall be buried when possible. All drain connections shall be piped aboveground. The centerline of hand wheels shall be approximately 42" above grade or platform deck and be a minimum of 24" in diameter.

Wedge gate valves or reduced bore through-conduit or ball valves shall be used in piping which will not be pigged. Where reduced bore valves are used, the valve inlet and outlet passages shall be specified to match the pipe internal diameter.

Check valves should not normally be installed in pipelines which will be pigged, but consideration may be given to installing check valves of special design capable of passing pipeline pigs. Check valves shall be swing-check type conforming to API 6D. All check valves 16-inches or larger will be equipped with slam retarders. Check valves with external swing arms or counterbalances are allowed only if protruding guarding is installed.

Ball valves size 18-inches and larger should be trunnion-mounted and equipped with a secondary seal system to provide shut-off in the event of failure of the primary seal.

Valves on offsite pipelines shall be weld-end. Where valves are fitted with electric actuators and are employed in cathodically protected piping, particular attention shall be given to electrical isolation of the actuator from the valve in order to avoid leakage of cathodic protection current.

The rating of valves should be sufficient to satisfy the maximum operating and test pressure of the pipeline, subject to the pressure/temperature limitations given in ASME B31.4 and ASME B31.11. Valves to be employed for hot-tapping shall be selected with due regard to the capabilities of hot-tapping equipment available.

Valve operators shall be off-the-shelf design, SPR standardized and manufactured of suitable materials for the service and duty required to reliably operate the valves under all operating conditions in accordance with the specifications.

8.3.4 VALVE LOCATIONS AND SETTINGS

In general, for crude oil pipelines, valves shall be installed in the mainline to sectionalize the line in 15-mile maximum sections. Valves shall be installed at locations near roads or other locations that are accessible to operating personnel whenever possible. Valves should also be located on both sides of "special hazard" areas - river crossings, etc. Mainline valves shall have 2-inch riser connections installed on either side of the valve. The risers shall have 2-inch valves installed aboveground.

All valves, including mainline, manifolds, control valves, motor valves, etc., shall be located to be accessible for normal operation. In general, mainline valves and other valves located an impractical distance from a power source shall be hand wheel-operated. Mainline valves located at launcher and receiver settings, all frequently operated process valves, and all process valves 12-inches and larger shall be power operated. Motor operated valves shall have the capability of travel reversed locally or remotely from the Central Control Room.

All crude oil pipeline valves on DOE-operated (non-leased) pipelines shall be equipped for remote operation with communication to the DCS. In remote locations where a power source is not available or practical, hydraulic operators with battery backup and satellite communication and control shall be installed.

8.3.5 PIGGING FACILITIES

All pipelines shall be provided with facilities to enable the lines to be pigged before commissioning and, if required, during subsequent operation and for maintenance inspection.

Pig receiving and launching traps or spool pieces shall be installed at suitable locations to enable the required pigging and testing operations to be performed. The door at receiving and launching ends shall be "quick-open" type. Provisions shall be made to connect the pig receiver to the oil drain system. All block valves in lines which are to be pigged shall be full bore through-conduit gate valves or full-bore ball valves. Pipeline field bends in lines which are to be pigged shall have minimum radii in accordance with this chapter. Manufactured fittings shall have a minimum radius of five pipe diameters.

Where branches are 25 percent or more of the main line diameter, tees shall be employed and shall be fitted with scraper guide bars. Branches less than 40 percent of main line size may be installed using approved weld-o-lets if allowed by the respective design code.

The design shall consider the use of "smart" pigs and pigs with audio signaling capability, as methods of locating pigs in pipelines. Pigs with audio capability are preferred; radioactive pig detectors are not recommended.

Scraper trap design, materials and manufacturing processes shall meet the requirements of the applicable piping code. The scraper barrel shall be sized to launch and receive internal pipeline inspection equipment. Scraper barrels shall be equipped with an internal cradle for 30-inch and larger pipelines. Closures shall be equipped with horizontal hinge and closure access tools. Scraper settings shall be equipped with a spill pad and scraper trolley outside of scraper barrel to move scrapers to or from barrels, and a jib crane to handle scrapers to and from trucks. Scraper traps must be designed so that all crude oil can be drained from the trap and piping prior to inserting or removing scrapers/pigs. Scraper traps must be vented to prevent air from being metered through the pipeline. On scraper traps larger than 30-inches, a 1-inch diameter, valved equalizing line will be installed from the barrel to the throat of the launcher to equalize the pressure across the pig when filling the trap prior to launching. Design shall keep from jamming the pig in the trap launch valve.

Thermal expansion relief valves, pressure indicator pig-signals shall be provided with appropriate drain and vent connectors.

8.3.6 VENTS, DRAINS, THERMAL RELIEF

Vent connection shall be installed at high points at each pig trap and valve station on the pipeline. Drain valves should be installed at each end of a pipeline, adjacent to each section isolating valve and also, if required, at low points along a line. Vent and drain valves shall be 1-inch minimum for lines up to 12 inches and 2-inch minimum for lines above 12 inches. These minimum sizes may, however, be increased in accordance with site-specific requirements of a particular project. After commissioning of buried lines, vent valves, apart from those in fenced areas, shall be blanked off, hand wheels removed, the valve assemblies completely protected with bitumen or similar coating and the trench backfilled. If drain valves are not enclosed within fenced areas they shall be treated in a similar manner. Pipeline markers inscribed "VENT" and/or "DRAIN" shall be installed adjacent to each buried valve. After commissioning of aboveground lines, the vent valves or drain valves should be blanked off and the hand wheels securely locked in the closed position.

Thermal relief valves shall be fitted to all sections of aboveground pipelines that could be isolated between closed main line valves (or buried pipelines when necessary). Thermal relief valves shall also be fitted to crude oil scraper and receiving traps. Thermal relief valves shall be provided with block valves between the origin point and the relief device that can be locked or sealed in the open position. All thermal relief valves shall be balanced against the effects of back pressure (to ensure a constant set pressure against a variable back pressure) where it will dump into a pressurized system or container.

8.3.7 ABOVEGROUND PIPELINES

If possible, all pipelines shall be buried, but short sections of lines 12 inches or smaller may be laid aboveground except where protection from diurnal temperature variation is required or where the line passes through populated areas. All larger lines shall be buried and only laid aboveground where the terrain would make burial impracticable.

Aboveground pipelines shall be laid on concrete supports where the ground conditions are suitable. A minimum clearance should be maintained between the ground and the bottom of the pipeline. This should normally be 8 inches in rocky areas increasing to 24 inches where there is a danger of sand accumulation.

In areas subject to inundation; in areas of blown sand; at gully or dry water course crossings; and in natural drainage areas, aboveground pipelines shall be laid on H-supports. The height of support shall be selected to suit local conditions, but they shall be sufficiently high to keep the bottom of the pipeline at least 2 feet above the highest recorded flood level.

Aboveground pipelines shall be designed with a configuration to accommodate thermal expansion. Where restraint is necessary, pipeline anchors and a flexible pipeline configuration shall be designed. In those instances where the pipeline is fully restrained the wall thickness shall be increased to withstand the thermal stress. Calculations shall be supplied to substantiate the design.

Pipeline anchors shall be designed to site-specific conditions, and particular ground conditions may necessitate special consideration (e.g., marshy and sandy areas). Hillside anchors shall be installed on steep, hilly sections to restrict pipeline movement and to maintain the combined stress in the pipeline wall within acceptable limits. Stress calculations shall take into account the effect of the weight of the pipeline and contents of the longitudinal stress in the pipeline.

In all cases, aboveground pipelines shall be painted for external corrosion protection. A corrosion allowance on pipe wall thickness shall be included where climatic conditions or the ground being traversed require. Buried sections of aboveground pipelines (e.g., at road crossings) shall be coated. Exposed lines installed on bridges or pipeway shall comply with the design and comply with the installation requirements of the bridge or pipeway owner.

8.3.8 BURIED PIPELINES

All pipelines shall be buried unless the pipeline length is relatively short or where the terrain would make burial impracticable. Buried pipelines shall be coated externally and cathodically protected against corrosion.

The trench width shall be not less than 1 foot wider than the pipeline diameter in all ground conditions including rock. The trench shall be sufficiently deep to provide a 6-inch minimum of soft padding around the pipeline and a 3-foot minimum of cover between the top of the pipeline and the mean graded level of the right-of-way.

The depth of cover may be reduced to 2 feet in rocky ground under certain circumstances, e.g., in isolated locations where vehicles would be unlikely to cross over the pipeline. In built-up areas, in heavily cultivated areas, at dry water courses and where vehicles are likely to cross the pipeline, the minimum cover should be increased. In addition to the minimum cover specified for the pipeline, the trench back-fill shall be crowned to a height between 8 and 12 inches above the surrounding ground. However, crowning may be omitted in built-up and heavily cultivated areas where increased depth of cover is specified. Crowning should always be omitted at dry water course crossings.

8.3.9 CROSSINGS

Crossing designs will comply with API-RP 1102 except as noted below.

A minimum 1 inch of concrete coating on 10.750-inch and larger carrier pipe shall be used as protection from external forces on all cased and uncased crossings and extends across the entire right-of-way of the crossed facility (road, railroad, etc.). Increased wall thickness is preferable to casing at all crossings.

8.3.9.1 Road and railroad crossings shall remain at the same grade and meet the design specifications of the owner or the governing authority of the facility being crossed, as specified in the crossing permit.

Open cut crossings of paved and unpaved roads shall be restored to the owner's specifications. The pipe wall thickness shall be increased within the right-of-way of all uncased public roads and highways. Pipe shall be concrete coated or installed with casing insulations in cased crossings. Spacing of casing insulators shall be on five-foot centers or less and doubled at the ends.

Unpaved roads may be open cut with the approval of the local authority as specified in the permit.

Minimum cover to road and railroad ditches shall be 5 feet above the top of the casing. Minimum cover at center line of roads shall be 5 feet. Minimum cover at centerline of railroad crossings shall be 5'-6" to bottom of rail. Permit requirements may supersede these minimum dimensions. Crossings of railways shall be made without interruption of railway traffic. If the railway is on an embankment, the crossing should preferably be made under an existing bridge. If this is not possible, the pipeline should be laid in a thrust or auger bored casing pipe with concentric insulating supports.

Although not preferred, casing may be required as a means of protecting the pipeline from external forces, in consideration of construction requirements (generally bore distances greater than 100 feet), and as required by owners and jurisdictional agencies of the crossed facility.

8.3.9.2 Stream and canal crossings shall meet the design requirements established in the specific permit by the governing authority. Minimum depth of cover under bottom of streams shall be 4 feet unless otherwise specified in permits. The negative buoyancy requirements to preclude flotation of the pipeline is a pipeline specific gravity (pipeline void) of 1.3 for marsh and offshore. The specific gravity shall be based on seawater for offshore and saltwater canal crossings. Reinforced concrete coating shall be used to obtain negative buoyancy where possible.

Elevated pipe supports shall be high enough to carry the line at least 6 feet above maximum flood level. This clearance shall be increased if there is a likelihood of large floating objects being carried by flood waters and where the river is navigable. Normally elevated pipe supports shall be of the insulated type if the pipeline is to be cathodically protected.

8.3.9.3 **Major River Crossings**

At major river crossings, pipelines shall be laid under the riverbed. The method of crossing the river shall be selected for the particular circumstances and a site-specific design developed. For major navigable rivers, dual pipelines shall be evaluated against directional drilling and the cost impact of crossing loss in a formal crossing risk analysis.

Pipelines laid under the riverbed shall be coated and wrapped in accordance with River Crossing Protective Coating Specifications and weight coated to give a negative buoyancy sufficient to restrain the pipeline in position at all times, during construction and subsequent operation. The weight coating should normally be designed to maintain pipeline stability in mud of specific gravity 1.2, but the nature of the riverbed should be taken into account in each case. Depth of cover of pipelines installed under the riverbed shall be selected for the particular application to prevent damage to the pipeline when it is installed. A minimum depth shall be 5 feet or as required by the governing authority, whichever is greater.

Isolating valves shall be installed in erosion protected, fenced areas on both sides of major river crossings (at a maximum distance of 75 feet beyond adjacent levees or 150 feet from the riverbank/riverbed where no levee is present). If installed in valve pits, the top of the pits shall be above maximum recorded high-water level.

A survey shall be made of each major river crossing between block valves to provide the following details: elevation of riverbanks; elevation of riverbed at maximum intervals of 50 feet; water level at time of survey; maximum recorded high water level; minimum recorded low water level; current velocity at time for surveys; maximum anticipated current velocity; details of any bridges, jetties or other features within 300 feet upstream or downstream of the river crossing.

Trial borings shall be required at selected locations to determine the nature of the riverbed.

If field-bent sag bends and overbends are utilized, the sag bends shall be placed a minimum of 15 feet into the banks. Banks shall be stabilized using stone rip-rap, cement/sand sack breakers, bulkheads, or other methods as may be required by local conditions.

River crossings shall be designed as free stress crossings. River crossing warning signs shall be installed on both banks of navigable waterways.

Reinforced concrete coating shall be used to obtain negative buoyancy. The negative buoyancy shall be a minimum of 1.3 in the mud for all river crossings.

8.3.9.4 Levee Crossings

Levee crossings shall be designed to meet the requirements of the levee governing authority as specified in the permit.

8.3.9.5 Pipeline Crossings

Where above-ground pipelines cross each other, a minimum clearance of 1½ feet shall be maintained between adjacent lines. Where an aboveground pipeline is to cross an existing buried pipeline, means shall be provided to allow continued use of the buried pipeline right-of-way.

Where a buried pipeline is to cross an existing aboveground pipeline an increased depth to cover shall be specified for the whole width of the right-of-way. Where a buried pipeline is to cross an existing buried pipeline, the new line shall pass under the existing line where practical. If not practical, the new line shall pass over the existing line and the existing line shall be lowered as required to provide adequate clearance. A minimum clearance of 1½ feet shall be maintained between crossing pipelines.

Where a pipeline crosses an existing pipeline of other ownership, the design of the crossing and cathodic protection shall satisfy the requirements of the other owner.

Potential test points, current test points and bonding points (direct and resistance) shall be installed on both lines at the crossing to enable the cathodic protection systems to be interconnected if required.

For a minimum distance of 50 feet on either side of the pipeline crossing, the new pipeline shall be double wrapped when a coal tar enamel and felt wrap coating system is used.

Pipelines that cross in the marsh, subsea or beneath rivers shall have grout bags placed between them to ensure separation is maintained.

8.3.9.6 Thermal Expansion and Flexibility

Thermal expansions may cause movements at points where lines terminate and cause excessive forces on equipment, valves or connecting piping. Suitable anchors and adequate flexibility shall be designed to limit excessive movement.

Flexibility and expansion design shall meet the requirements of the applicable code listed in Table 8-1.

Pipelines buried with the depth of cover recommended herein shall be assumed to be fully restrained by the backfill and thermal expansion contained.

8.3.9.7 Pipeline Anchors

Pipeline anchors for buried lines up to 36 inches shall be in accordance with standard design for each storage site area but particular attention shall be paid to the special requirements in areas where ground conditions are poor, as in marshy, or sandy areas. Pipeline anchors for buried pipelines above 36 inches shall be specially designed for the particular application. Pipeline movement at end points of buried pipelines and at other locations where the pipeline rises aboveground level for tie-in connections, etc., must be considered and accommodated by flexible pipeline configurations and anchors as necessary.

Where a buried pipeline passes through areas subject to seasonal inundation or passes under dry water courses, consideration shall be given to the need for concrete coating or the installation of anchors or anchor weights. Anchor weights shall be required to restrain the line in such areas only during construction before the trench is backfilled and the line filled with liquid; however, anchor weights shall be required whenever there is a danger of backfill being washed out or becoming waterlogged. The pipeline shall be designed for a specific gravity (pipeline void) of 1.3 for offshore and bayou crossings. The specific gravity shall be based on seawater for offshore and saltwater canal crossings. When calculating negative buoyancy, the density of waterlogged backfill mud shall be taken into account.

8.3.10 PIGGING AND TESTING

Pipelines shall be pigged and hydrostatically tested before commissioning. The hydrostatic test pressure shall be not less than the pressure required to comply with the relevant requirements of ASME B31.11, ASME B31.4 and 49 CFR 195. The maximum test pressure at the lowest elevation point in any section of the pipeline shall be the pressure equivalent to 95 percent of the minimum specified yield strength of the pipe steel. Test pressures in excess of 95 percent yield shall not be specified.

8.3.11 PIPELINE MARKERS AND AERIAL SIGNS

Pipeline warning and identification signs shall be installed at all road crossings, stream or canal crossings, valve settings, and at fence and property lines as required by 49 CFR 195 and API RP-1109.

Aerial mile post marker signs shall be placed at intervals of one mile at a fence line, etc., nearest the actual mileage location.

Pipeline markers shall be installed at the following locations along buried pipelines: at every mile post from the start of the pipeline; at all major changes in direction of the pipeline; at both sides of every road, railway and underwater crossings; at changes in wall thickness; at branches for future use; and at vent and drain valves.

All signs shall be designed, fabricated, and installed to give maintenance free service.

8.4 PIPELINE LEAK DETECTION AND LOCATION SYSTEMS

For the crude pipelines operated by DOE, a leak detection system/method shall be employed in compliance with API 1130 (2007) for both static (non-flowing) and dynamic (flowing) conditions. Each pipeline shall be individually evaluated to determine the physical characteristic of the pipeline, and these characteristics shall only be applied to that specific pipeline. The system/method shall be monitored in the Control Room via a stand-alone system and/or the DCS. periodic retesting /evaluation shall be performed to ensure the system is still functioning as designed/accepted.

STATIC: After the pipeline temperature and pressure has stabilized, the system shall monitor the pipeline in a non-flowing condition. The pipeline pressure shall be maintained between 50 and 150 psig. The acceptable leak size (diameter) shall be determined by a pipeline hydraulic analysis and field testing. For a leak size to be acceptable, the system must detect AND accurately locate the leak. The leak condition shall alarm in the Control Room and also indicate the approximate leak location.

DYNAMIC: The system shall monitor the pipeline while in a flowing condition and be capable of detecting a leak of 2% or greater of flow between the minimum and maximum flow rate for the specific pipeline. The flow data (meter skids, flow meters, etc.) from each end of the pipeline shall be transmitted to the control room and calculations performed automatically at a prescribed time interval to determine the flow differential from each end of the pipeline. The leak condition shall alarm in the control room. Where circumstances or infrastructure do not allow for the use of an automated system, then a manual system shall be used to accomplish the same automated function.

TABLE 8-1

DESIGN CODES & SPECIFICATIONS		
	CRUDE OIL	**RAW WATER & BRINE**
DESIGN	CFR 49 PART 195 ASME B31.4	CFR 49 PART 195 ASME B31.4
PIPE	API 5L ASTM A-106	API 5L ASTM A-106
FLANGES	MSS-SP-44 ASME B16.5 ASME B16.11	MSS-SP-44 ASME B16.5 ASME B16.11
FITTINGS	ASME B16.9 MSS-SP-75	ASME B16.9 MSS-SP-75
VALVES	API 6D API 602	API 6D API 602
WELDING PROCEDURES AND WELDER QUALIFICATIONS	CFR 49 PART 195 API 1104	ASME IX OR API 1104
WELD ACCEPTANCE & INSPECTION CRITERIA	CFR 49 PART 195 & API 1104 (1)	API 1104 (1) (2)

* PIPE SUPPORT STRUCTURES OR COMPONENTS, INCLUDING NON-INTEGRAL SUPPORTS, MAY BE WELDED PER ANSI / AWS D1.1

(1) RADIOGRAPH 100% OF GIRTH WELDS
(2) SEE SPECIFIC TASK PACKAGE FOR CEMENT-LINED PIPELINES FOR WELD AND INSPECTION REQUIREMENTS

FIGURE 8-1

FRICTION FACTORS FOR ANY TYPE OF COMMERICAL PIPE

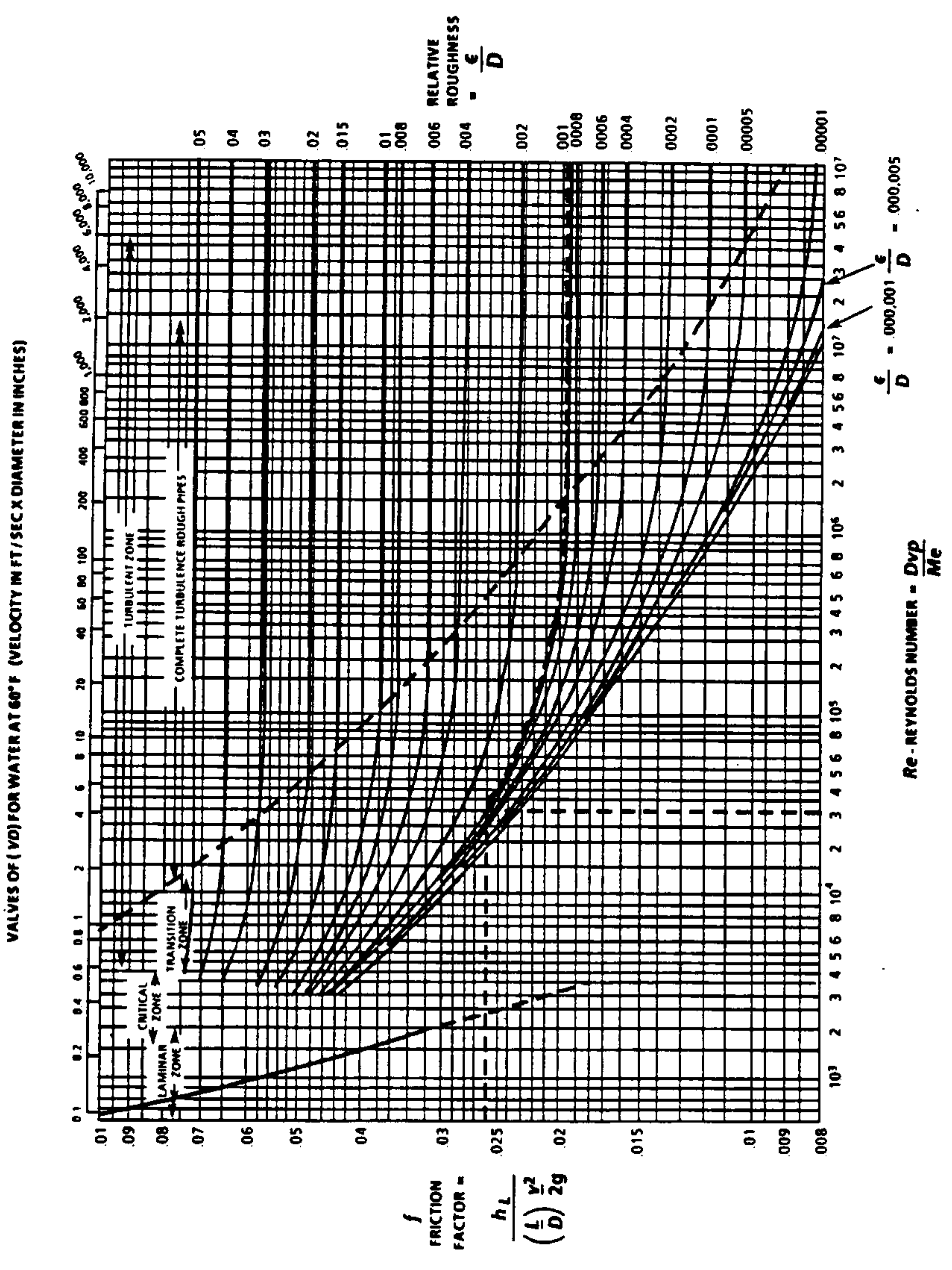


FIGURE 8-2

RELATIVE ROUGHNESS OF PIPE MATERIALS AND FRICTION FACTORS
FOR
COMPLETE TURBULENCE

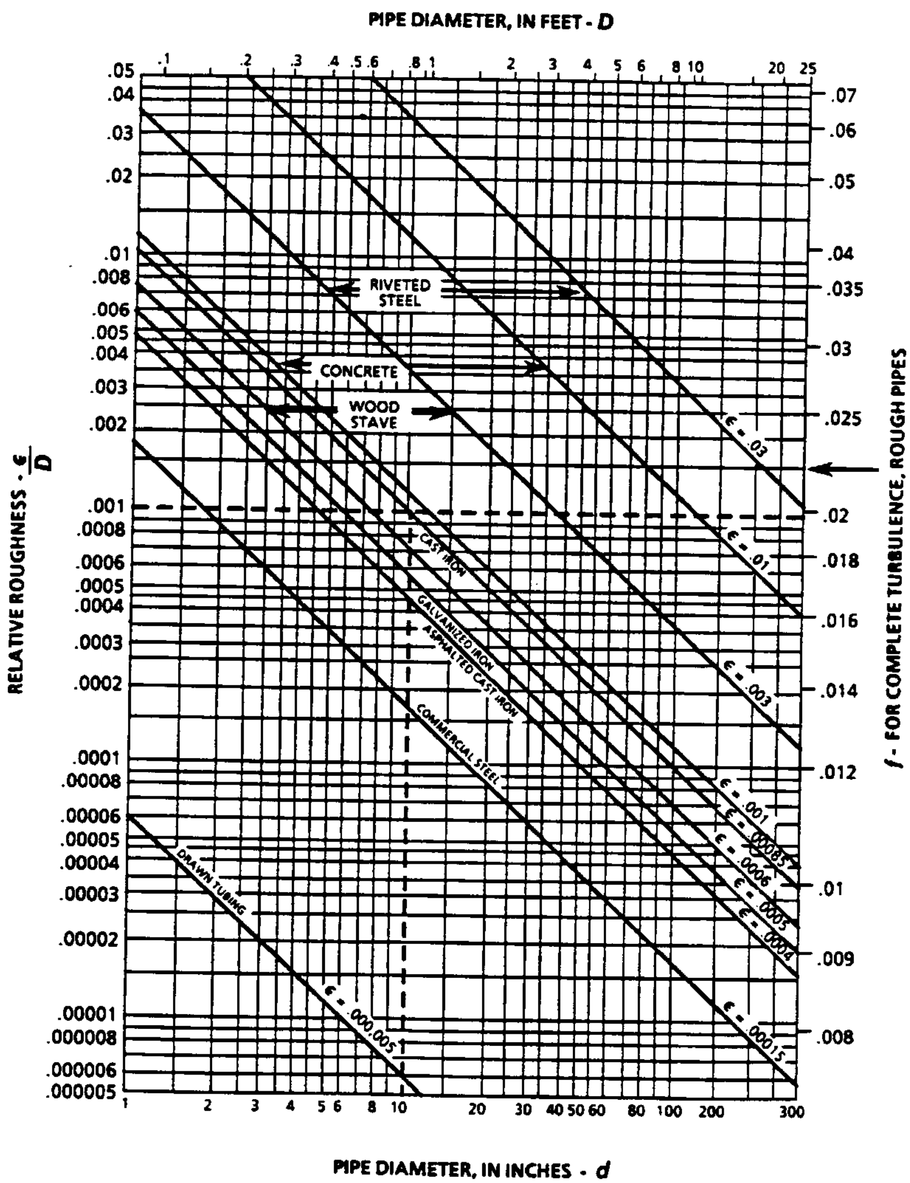


FIGURE 8-3

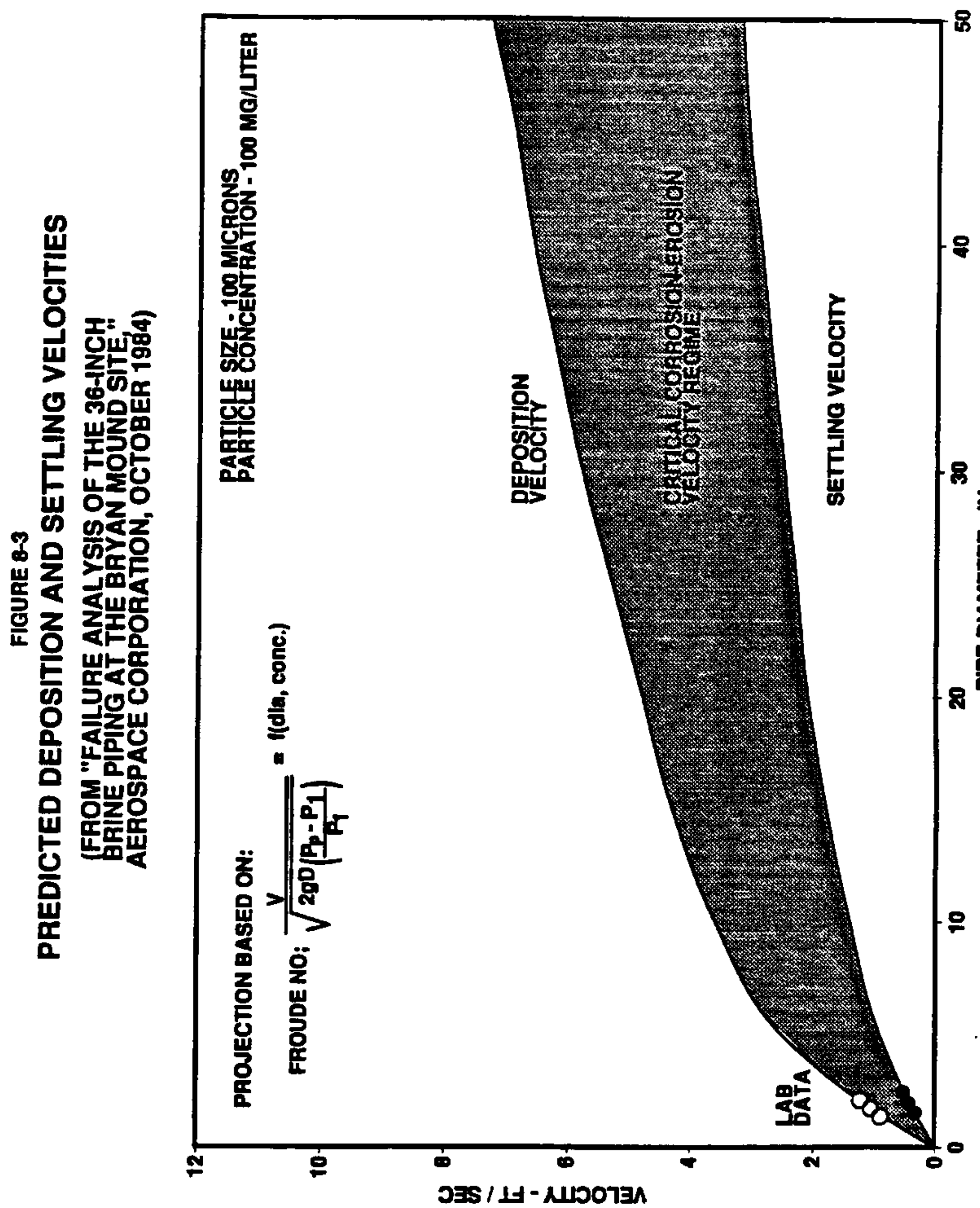


FIGURE 8-3
PREDICTED DEPOSITION AND SETTLING VELOCITIES
(FROM "FAILURE ANALYSIS OF THE 36-INCH BRINE PIPING AT THE BRYAN MOUND SITE," AEROSPACE CORPORATION, OCTOBER 1984)
PROJECTION BASED ON:
FROUDE NO; $\frac{V}{\sqrt{2gD\left(\frac{P_p - P_1}{P_1}\right)}}$ = f(dia, conc.)
PARTICLE SIZE - 100 MICRONS
PARTICLE CONCENTRATION - 100 MG/LITER
LAB DATA
DEPOSITION VELOCITY
CRITICAL CORROSION/EROSION VELOCITY REGIME
SETTLING VELOCITY
VELOCITY - FT / SEC
PIPE DIAMETER - IN.
0
2
4
6
8
10
12
0
10
20
30
40
50

CHAPTER 9

OIL ACCOUNTABILITY AND CONTROL

9.1 PURPOSE

This chapter establishes design requirements to be implemented for Strategic Petroleum Reserve (SPR) complexes to ensure properly and adequately designed crude oil accountability and control (OAC) system. All design requirements associated with testing of water will be addressed in Chapter 10.

9.2 CUSTODY TRANSFER POINTS

Crude oil measurement required at each custody transfer point shall be accomplished by metering systems or storage tank measurement. Metering systems shall be designed and demonstrated accurate by flow testing to within plus/minus 0.25 percent of total volume transferred. Storage tanks used for custody transfer of SPR specification crude oil shall be certified and Department of Energy (DOE) provided with strapping tables which are calibrated in accordance with American Petroleum Institute (API) standards. Measurement systems shall be designed so that they will not interrupt flow if components malfunction during either fill or drawdown.

9.2.1 CRUDE OIL SAMPLING

An automatic variable proportionated sampling system shall be installed to collect representative samples of each SPR crude oil stream as it leaves or enters DOE owned equipment in accordance with applicable API, Manual of Petroleum Measurement Standards (MPMS).

9.2.2 CRUDE OIL TESTING LABORATORY

The designer shall provide for an onsite Government laboratory sufficient to house the equipment, provide storage for samples, and be otherwise equipped to conduct the tests listed in Table 9-1. For any additional crude oil tests, samples will be shipped to either the SPR Big Hill Storage facility or a DOE-specified laboratory for analysis.

As an alternative to providing an onsite Government laboratory, an approved third-party testing service with current certifications/ accreditations can be utilized to conduct the tests listed in Table 9-1.

TABLE 9-1

REPRESENTATIVE CRUDE OIL TESTS

	Storage Site	ASTM Primary Test Method
Gravity, API@ 60ºF	X	D-1298 or D-5002
Water and Sediment Vol. %	X	D-4007, D-4928, and D-4807
Reid Vapor Pressure PSIA @ 100ºF	X	D-323 or D-5191
Total Sulfur, Mass %	X	D-1552 or D-4294

9.2.3 SAMPLE STORAGE

The designer shall provide for a weatherproof, ventilated repository to retain U.S. gallon/quart size samples of crude oil for a period of 60 days except for 7-year cavern samples, which will be retained for a period of 2 years.

9.2.4 METERING

Meters provided by DOE for custody transfer shall be designed in accordance with API MPMS, relative to flow measurement using electronic metering systems for custody transfer of crude oil. Meter selection accuracy shall be based on a linearity of plus/minus 0.25 percent of reading over normal flow range (accuracy of any specific flow rate shall be 0.1 percent) with a 0.02 percent repeatability and an expected 25-year life.

Individual cavern oil metering systems shall be accurate to within 2.0 percent of the gross standard volume (GSV). Calculations for GSV shall consider flowing temperature and pressure conditions.

CHAPTER 10

ENVIRONMENTAL

10.1 PURPOSE

This chapter establishes the Strategic Petroleum Reserve (SPR) criteria to be incorporated into the design of each SPR site to ensure that appropriate environmental aspects and impacts have been considered and adequate environmental safeguards have been provided

10.2 OTHER ENVIRONMENTAL DOCUMENTS

This section establishes the criteria that all designs shall comply with the National Environmental Policy Act (NEPA) and the SPR Environmental, Safety and Health (ES&H) standards list in a timely fashion to allow acquisition of necessary permits/approvals.

10.3 DESIGN REQUIREMENTS

10.3.1 LAND FEATURES

10.3.1.1 Geology. The purpose of site characterization studies and geological environmental design criteria is to provide data necessary to prevent oil seepage from salt caverns, or surface facilities and equipment into the adjacent strata.

The United States is classified into four zones delineating seismic risk. The authorized SPR Program is located in Zone 0. The design shall consider these risks and shall incorporate those features appropriate to minimize seismic effects in accordance with Zone 0.

The SPR requires predevelopment surveys to include sonar caliper surveys to delineate the boundaries of the storage cavity and lists specific guidelines to be followed during the design of storage caverns to minimize oil seepage from the cavity.

Subsidence monitoring monuments shall be included in the site design.

10.3.1.2 **Land Use.** The selection and design of an SPR site must comply with Federal, state, and local land use plans, including the Coastal Zone Management Act of 1972, the Endangered Species Act of 1973, Executive Order 11990, Protection of Wetlands, and subsequent relevant Orders. Structures shall be sited to minimize impact to wetlands, sensitive habitat, and to the public to the maximum extent practicable. Where such impacts cannot be avoided, the design shall incorporate appropriate mitigative measures, including those necessary to meet all applicable laws, regulations, and Federal Orders.

10.3.1.3 **Topography.** The topographic setting of each site shall include sufficient area for required surface facilities. Executive Order 11988, Floodplain Management and subsequent relevant Orders require projects to be "flood-proofed." The flood protection provided, however, shall not increase the surface elevation of the 100-year flood by more than one foot. For sites to be constructed in coastal areas consideration shall be given to the effects of storm driven waves and debris.

10.3.2 WATER ENVIRONMENT

10.3.2.1 Surface Waters

10.3.2.1.1 **Process Water.** State permits may be required to withdraw water from existing sources for process (see Chapter 3). Discharge of process water will require Federal and/or State permits.

10.3.2.1.2 **Effluent Standards.** The design shall meet the requirements of the Federal Water Pollution Control Act (FWPCA), as amended, to achieve a standard of performance that represents the best available demonstrated control technology.

A National Pollutant Discharge Elimination System (NPDES) and/or corresponding State permit is required. Application procedures are specified in Title 40 CFR, Part 122, Subpart B (NPDES), and corresponding Louisiana and Texas regulations.

10.3.2.1.3 **Oil and Hazardous Substances.** The design shall meet the FWPCA, as amended; 40 CFR 110, Environmental Protection Agency, Water Programs Discharge of Oil; 40 CFR 116, Designation of Hazardous Substances; 40 CFR, Part 302, Designation of Reportable Quantities and Notification; and 49 CFR 195, Transportation of Hazardous Liquids by Pipeline.

The designer shall incorporate all practical measures to limit the risk of release of oil and hazardous substances and provide containment and/or other mitigative protection. Use of hazardous substances in construction and operational processes shall be avoided, incorporating alternative products where available. Where use of a hazardous substance is necessary, the quantity of that substance should be limited such that catastrophic release will not exceed the reportable quantity (40 CFR, Part 302).

10.3.2.1.4 **Oil Spill Prevention, Control, and Countermeasures.** Oil Pollution Prevention, 40 CFR 112, establishes procedures, methods, and other requirements to implement Section 311 of the FWPCA, under jurisdiction of the U.S. Environmental Protection Agency (EPA).

The designer shall prepare a list of requirements based on the guidelines in

40 CFR 112; the operating contractor shall prepare the Spill Prevention, Control and Countermeasure (SPCC) Plan and Facility Response Plan (FRP) based on this list. The SPCC plan shall be reviewed and certified by a registered Professional Engineer and maintained with the FRP at the facility for on-site review.

The design shall include one or more of the following preventive systems working in conjunction with each other: impervious dikes, berms or retaining walls; culverts, gutters, or other drainage systems; curbing; weirs, booms, or barriers; retention ponds; and sorbent materials. 40 CFR 112 provides detailed requirements on preventive systems that shall be incorporated into the design of storage and transfer facilities.

Oil spills fall under the jurisdiction of the EPA for non-transportation-related facilities, including oil storage facilities. The design shall also meet U.S. Coast Guard requirements for oil spill prevention at marine terminals as presented in 33 CFR 154 and 156; and Department of Transportation (DOT) requirements for pipelines as presented in 49 CFR 195.

Note: For CO cavern wells and well pads, Louisiana Statewide Order 29-M and the Clean Water Act requirements apply to spill control and containment.

10.3.2.1.5 **<u>Ocean Brine Disposal</u>.** The design shall meet 40 CFR 227 and 40 CFR 122 (NPDES) requirements for discharges. The designer shall ensure that the full range of ambient conditions of the physical, chemical and biological environment at candidate discharge sites, as described by baseline oceanographic data collections, are accommodated in meeting diffuser performance criteria. Monitoring methods shall be included in the design.

10.3.2.1.6 **Deep Well Brine Disposal.** Detailed discussions of the environmental impacts of deep well brine disposal are presented in site Environmental Impact Statements. The data presented in these documents shall be incorporated into the brine disposal system by the designer, as well as the surface water requirements of this chapter.

10.3.2.1.7 **Dredging.** The design shall consider construction in accordance with the River and Harbor Act of 1899; 33 USC 1344, Federal Water Pollution Act (FWPCA); 40 CFR 230, Guidelines for Specification of Disposal Sites for Dredged or Fill Material, and 33 CFR 320, COE Permit Requirements. The designer should refer to the site EIS for each site, as well as appropriate laws and regulations for background data and mitigating actions for dredging operations. Dredge and fill activities require a federal authorization issued by the COE, and corresponding state authorization.

10.3.2.2 **Surface Water Drainage and Impoundments**

All surface impoundments to be constructed may be lined to prevent release or infiltration of oily or other wastes to surface waters or into soils or groundwater. Liners shall be compatible with the product to be contained. A permeability equivalent to 1×10^{-7} cm/sec over two feet is typical for some impoundments; however, the lowest permeability specified by applicable state and Federal requirements shall be incorporated into impoundment design.

Surface drainage shall be provided to prevent pooling of water, erosion, or contamination of receiving waters with particulates. Silt fencing or equivalent shall be provided for, as appropriate, at construction sites. The designer shall incorporate provisions to prevent incidental contamination of storm water by oily equipment, storage areas, etc., exposed to rainfall.

10.3.2.3 Groundwater

The design shall meet the requirements of this Criteria, the Safe Drinking Water Act, the Clean Water Act, 40 CFR 146 and 250.45. Louisiana and Texas have regulatory responsibility for implementation of disposal well/storage cavern regulations. Underground storage tanks, when installed, shall meet state regulatory requirements. However, the designer shall avoid the use of underground storage tanks where aboveground tank options are feasible. The designer should also refer to the mitigating actions, groundwater conditions, and soil types described in the EIS for each site as well as regulatory criteria to assure that facilities and structures do not contribute to groundwater contamination.

10.3.3 SOLID WASTES

The design shall meet the requirements of Resource Conservation and Recovery Act (RCRA) PL 94-580. The designer shall always consider first reduction, then reuse, and then recycling of by-products in the design in order to minimize waste generation. On-site disposal of hazardous waste is strictly prohibited at all SPR facilities. On-site disposal may be utilized for certain non-hazardous wastes, if applicable permits are obtained. The designer shall incorporate site data from the site EIS, guidelines from the applicable sections of RCRA and applicable State requirements into the design of a disposal site. In the event a contractor is utilized for solid and/or hazardous waste disposal, the contractor’s collection, transportation, and disposal methods shall comply with the RCRA and corresponding State standards.

10.3.4 AIR QUALITY

The design shall meet the Clean Air Act (CAA) and other State and local requirements. Appropriate emission control devices shall be installed on SPR equipment and facilities. All applicable New Source Performance Standards (40 CFR, Part 60) shall be incorporated into the design. The impact of incremental emissions on overall site emissions shall be considered in design, so as to maintain minor facility status wherever feasible. Should a design cause a facility to be classified or reclassified as a major facility, the designer shall provide for all additional control technologies that become necessary for the facility.

Chlorinated fluorocarbons (CFC's) shall be eliminated from designs per current legislation, orders, regulations, and international agreements.

10.3.4.1 **Emission Limits.** The design of SPR sites shall be consistent with requirements of the CAA, as amended. The storage systems shall restrict petroleum hydrocarbon evaporative flash emissions such that they do not cause or contribute to violation of hydrocarbon and photochemical oxidation standards. Storage of crude and finished products, in tanks, except residual fuel oils, is regulated by New Stationary Source Performance Standards (NSSPS) (40 CFR 60, Subparts K, Ka, and Kb).

Emission controls using oxidation technology shall incorporate optimal destruction efficiencies, meeting both regulatory requirements and performance requirements consistent with overall facility emissions management limits.

10.3.4.2 **Storage Systems.** Required pollution abatement equipment will vary for each site, type of storage, ambient air quality, and type of product stored. The designer shall refer to 40 CFR 60, the Programmatic EIS for the SPR, the site-specific EIS's, and the American Petroleum Institute (API) codes for storage vessels, for appropriate design requirements.

10.3.4.3 **Transfer Operations.** State implementation plans regulate tanker operations while at port loading/unloading and ballasting/de-ballasting. These operations are a major hydrocarbon emission source at dock facilities. The SPR Final EIS specifies mitigation actions that may be employed to reduce emissions during the loading and unloading of tankers. The programmatic EIS for the SPR determined that losses from piping and pumps during transfer are minimal. Engineering practices shall be employed to minimize these emission sources.

10.3.4.4 **Off-Site Emissions.** State and Federal regulations limit the exposure of the public to certain pollutants, which may originate from SPR facilities. These may occur as the result of operational activities, as well as during construction or maintenance, and may pose health, safety, and property risks. The designer shall consider the potential for his design to create such risks through off-site emissions or releases and provide all necessary controls to preclude such impacts.

10.3.5 NOISE

Personnel shall be protected in their work environment per Occupational Safety and Health Administration (OSHA) noise standards. For sites near inhabited areas, it may be necessary to institute noise reduction with noise abatement designs based on background noise levels and mitigating techniques presented in the final EIS for the SPR and the site specific EIS's.

10.3.6 ECOSYSTEMS

Design considerations shall be given to eliminate or minimize any adverse impacts to the biotic and abiotic environment. Special attention should be given to wetlands and sensitive habitat. The designer shall ensure that all mitigating techniques specified in the EIS for each site are incorporated into the final design. Federal and state agencies shall be included early in the design process to identify issues and to improve the opportunities for mitigating impacts. The designer may need to provide specific mitigation proposals for approval, where certain impacts cannot be avoided.

10.3.7 ARCHAEOLOGICAL AND HISTORICAL PRESERVATION

Executive Order 11593, Protection and Enhancement of the Cultural Environment, and subsequent relevant Orders, requires Federal agencies to establish procedures to preserve the nation's cultural environment. Prior to an actual design, a review of the site-specific EIS shall seek to identify any potential archaeological or historical sites within or near the confines of the proposed site and associated pipeline routes. In addition, state historical preservation offices should be consulted where the potentials for cultural or archaeological sites exist.

10.3.8 MATERIAL SELECTION

The designer shall provide for use and incorporation of materials with recycled content, wherever feasible, in accordance with the requirements of Section 6001 of the RCRA Act, Executive Order 13101, and subsequent relevant Orders.

10.3.9 TESTING LABORATORY

Water Testing. The designer shall provide for an onsite Government laboratory sufficient to house the equipment, provide storage for samples, and be otherwise equipped to conduct the water analyses indicated below:

1. pH
2. Specific Conductivity
3. Salinity
4. Dissolved Oxygen
5. Chloride
6. Total Hardness
7. Total Suspended Solids
8. Total Dissolved Solids
9. Biochemical Oxygen Demand - 5 Day
10. Chemical Oxygen Demand
11. Oil and Grease
12. Total Organic Carbon
13. Fecal Coliform

CHAPTER 11

SAFETY

11.1 PURPOSE

This chapter establishes criteria for analyzing and controlling potential hazards and incorporating safety features during the design process.

11.2 HAZARD ANALYSIS

11.2.1 Designs for new facilities and equipment and modifications to existing facilities and equipment shall be analyzed or reviewed to identify potential workplace hazards and to evaluate the risk of associated worker injury or illness.

11.2.2 Designs shall be evaluated to determine the capability of the facilities to withstand natural phenomena (seismic, wind, flood, and lightning). The evaluation shall be based on an assessment of the likelihood of future natural phenomena occurrences and shall be conducted using a graded approach commensurate with the potential hazards. Designs shall consider potential damage and failure of systems, structures, and components due to both direct and indirect natural phenomena effects, including common cause effects and interactions from failures of other systems, structures, and components.

11.2.3 Designs shall consider proper illumination, safe walking / working surfaces, and adequate ventilation.

11.3 HAZARD CONTROLS

11.3.1 For hazards identified during the design process, controls shall be incorporated in the design. Hazard control methods shall be selected based on the following hierarchy:

- Elimination
- Substitution
- Engineering controls
- Work practices and administrative controls that limit worker exposures.

- Personal protective equipment.

11.3.2 Systems, structures, and components shall be designed, constructed, and operated to withstand the effects of natural phenomena as necessary to ensure the confinement of hazardous material, the operation of essential facilities, the protection of Government property, and the protection of life safety for occupants of Strategic Petroleum Reserve buildings.

11.4 FIELD ERGONOMIC HAZARD CONTROLS

11.4.1 Designs should be reviewed for potential risk factors that could contribute to the development of musculoskeletal disorders as covered under the General Duty Clause – Section 5(a)(1) of OSHA. Where possible, the control of these risk factors should use feasible engineering controls. Designs should incorporate provisions for instrumentation, control, and electrical component access that minimizes horizontal and vertical reach distances and allows operations and maintenance personnel to maintain neutral work postures and to minimize the necessity for repetitive motion and contact stress while operating or maintaining these components.

11.4.2 Designs should incorporate the following criteria for reach distances from stable work surfaces to the midpoints of manual valve handles or hand wheels:

- Horizontal reach distance – 10-18 inches.

- Vertical reach distance – 39 to 48 inches.

Where these distances are not possible, feasible work practice or administrative controls should be designed and implemented.

CHAPTER 12

FIRE PROTECTION

12.1 PURPOSE

This chapter provides programmatic and design requirements to maintain an "Improved Risk" or "Highly Protected Risk" level of fire protection and life safety for new and existing Department of Energy (DOE) Strategic Petroleum Reserve (SPR) facilities. This document seeks to address criteria for new facilities, requirements applicable to modifications/expansions to existing facilities and concerns pertinent to existing facilities. It is not the intent of the requirements to be retroactively applied to existing facilities unless specifically noted herein.

12.2 GENERAL REQUIREMENTS

The DOE SPR recognizes the following references. The most recent version of these documents is to be followed.

a. DOE Order 151.1D, *Comprehensive Emergency Management System*

b. DOE Order 420.1C, *Facility Safety*

c. DOE Standard DOE-STD-1066-2016, *Fire Protection*

d. 29 CFR 1910, *Occupational Safety and Health Standards*

e. 29 CFR 1926, *Safety and Health Regulations for Construction*

In addition to these documents, DOE SPR ASL5480.18, *Fire Protection Manual* (most recent edition) shall be used for requirements input.

Following from these references, the DOE SPR recognizes the full range of documents published by:

- National Fire Protection Association (NFPA)
  - Specific attention shall be given to NFPA 101, *Life Safety Code*
  - NFPA 5000 is excluded based on adoption of local building code
- FM Global (FM)
- International Code Council [International Building Code (IBC), International Fire Code (IFC), International Mechanical Code (IMC), etc.]

A limited list of such documents is included in Appendix A of these Level III criteria.

New structures shall use the latest edition of the documents, with the edition fixed once the project reaches the "code of record" stage. Modifications to existing structures shall consider the latest edition as much as practical and utilize the code of record where the latest edition cannot be implemented. Existing structures not implementing changes or upgrades shall follow their respective codes of record with regard to items such as construction, life safety, required fire protection and similar items.

12.2.1 IMPROVED RISK APPROACH

The noted documents all follow a general approach that supports the DOE "Improved Risk" philosophy that utilizes engineered systems (both active and passive) augmented by administrative controls. Where this chapter provides performance-based criteria or multiple approaches, an analysis of the various costs of protection versus possible damage and interruption of operations will be necessary to achieve an "Improved Risk" or "Highly Protected Risk" level of protection at a justifiable cost.

In considering the various combinations of systems and controls, passive systems are preferred first, active systems preferred second and administrative controls preferred only when passive or active systems cannot be implemented or when the hazard/issue can only be addressed by administrative controls.

The desired level of fire protection, life safety and hazardous materials control is to protect personnel and property against emergency occurrences and/or protect against an interruption in service. Based on known response times and capabilities, passive and active systems shall be considered over manual fire suppression efforts and spill control responses.

Fire suppression systems shall be provided as described by this document. The requirements described herein reflect the loss-limitation guidelines included in DOE Order 420.1C (latest revision) and DOE-STD-1066-2016, which include:

a. Required fire suppression for permanent structures over 5,000 ft^2 [DOE Order 420.1C and DOE-STD-1066-2016]

b. Required fire suppression where a fire loss exceeds $5.9 Million (in 2018 dollars *) [DOE Order 420.1C and DOE-STD-1066-2016]

c. Required multiple fire protection approaches (such as fire suppression and fire detection/alarms) where a fire loss exceeds $177 Million (in 2018 dollars *) [DOE Order 420.1C and DOE-STD-1066-2016]

d. Required fire walls or similar passive protection where a fire loss exceeds $412 Million (in 2018 dollars *) [DOE Order 420.1C and DOE-STD-1066-2016]

* Escalation is allowed per DOE Order 420.1C, Attachment 2:
"DOE G 413.3-21 Chg. 1, Cost Estimating Guide, Section 6.4.4 provides guidance on historical cost estimates and historical cost indexes. To convert 2018 dollar amounts to present value, an applicable historical cost index is selected, documented, and used, as described in DOE G 413.3-21."

e. Required process or containment systems for large releases of hazardous materials [DOE Order 420.1C and DOE-STD-1066-2016]

f. Required protection, process or containment systems to preclude shutdown or containment of critical programs or vital facilities/structures for a period of more than 15 calendar day [DOE SPR M&O Contract]

12.2.2 FIRE PROTECTION DESIGN ANALYSIS

A fire protection design analysis is required for all designs with the following scope:

- Modification of existing buildings that change/introduce occupancy types, modify egress routes or components, change overall construction type, modify operations (e.g., laboratory to waste storage) or modify more than 25% of the building
- New buildings that are normally occupied and house operations that are minimally necessary for site operations (e.g., control buildings, critical item warehouses, fire pump buildings, administrative buildings, etc.)
- New or existing structures housing or covering crude oil transfer equipment or related equipment necessary for storage/transfer mission (e.g., brine transfer pumps, pump enclosures, etc.)
- New or existing equipment and piping intended for crude oil transfer or related equipment necessary for storage/transfer mission (e.g.,

degasification structure, crude oil and brine pumps, storage tanks, heat transfer units, etc.)
- New or existing crude oil storage caverns and their surrounding areas

The design analysis shall address the requirements of the project as required by this chapter. The design analysis shall summarize fire protection design inputs prior to the design project initiation and shall be updated as the design progresses to ensure continued compliance throughout the process. The design analysis may be incorporated into a stand-alone document, design drawings or a combination of the two. The design analysis shall be submitted in accordance with SPR design review procedures.

When required, the design analysis shall discuss the following minimum topics (including those provided as an augmentation to minimum compliance), as they apply to fire protection, life safety and hazardous materials control within the specific project:

a. Building code analysis (i.e., type of construction, height and area limitations, building separation or exposure protection, interior finish ratings, etc.) using all codes identified for the project (e.g., IBC, NFPA 101, NFPA 30, NFPA 31A, NFPA 45, NFPA 400, etc.)

b. Classification of occupancy (under both IBC and NFPA 101)

c. Compliance with requirements identified in Section 12.2

d. Requirements for fire resistance rated, smoke rated and/or blast rated construction

e. Spacing requirements based on codes and standards (e.g., IBC, NFPA 30, etc.) and according to hazard analysis (e.g., radiant heat exposures from fires, explosion overpressure, chemical exposure limits, etc.)

f. Analysis of automatic sprinkler systems and water-based suppression systems, including protected areas and hydraulic analysis of required water demand

g. Determination of needed water supplies, water distribution (pipe sizing, pressure and flow requirements) and location of fire hydrants, monitor nozzles or other fixed water-based firefighting equipment

h. Indication of electrical classification zones and the required electrical rating (i.e., Class I, Division 1 or other)

i. Need for and general criteria for lightening protection systems

j. Identification of fire alarm system (the type of alarm system and location of the fire alarm equipment, type and placement of detectors, notification methods, connection to main site monitoring system, etc.)

k. Determination of requirement for gas detection systems and associated design criteria (i.e., type of detection system, location of detectors, gas detection zones, alarm and control panels, annunciators, alarm set points, etc.)

l. Indication of placement, type and size of fire extinguishers

m. Coordination with security and antiterrorism requirements

n. Coordination with environmental protection requirements

o. ERT, emergency response services and security access

p. Hazardous materials secondary containment location, sizing and protection (including at crude oil storage caverns)

12.2.3 FIRE HAZARDS ANALYSIS

When a project exceeds one of the loss criteria identified in Section 12.2.1, or at the direction of the SPR DOE Emergency Preparedness Manager or designee(s), a Fire Hazards Analysis (FHA) shall be performed for the project. The FHA shall be in accordance with the requirements of DOE SPR ASL5480.18, *Fire Protection Manual*.

12.2.4 FIRE PROTECTION ENGINEER OR SPECIALIST

As a minimum, all projects shall be given a cursory review by a designee of the SPR DOE Emergency Preparedness Manager (typically a site Fire Protection/Emergency Management Specialist, a Fire Protection Engineer attached to the Emergency Preparedness group or similar personnel) to determine if a full design review, fire protection analysis or FHA are necessary for the project.

Beyond the support discussed above, a licensed engineer with specialized knowledge in Fire Protection Engineering, shall be responsible for all design efforts that involve the following systems:

- Fire suppression systems, including water-based and those using other agents
- Water supplies, fire pumps, fire hydrants, monitor nozzles and similar equipment
- Fire detection and alarm systems
- Gas detection systems
- Fire resistance rated construction

12.2.5 AUTHORITY HAVING JURISDICTION

The Authority Having Jurisdiction (AHJ) for all projects is the SPR Project Manager of the Strategic Petroleum Reserve Project Management Office (SPRPMO). The SPR DOE Emergency Preparedness Manager or designee(s) shall be responsible for determining when alternatives, waivers, performance-based approaches or other methods reach the level of Exemption or Equivalency, both as defined in DOE Order 420.1C. When an Exemption or Equivalency is determined to be necessary, they shall be documented in detail as part of the project documentation and submitted for review and approval by the AHJ via SPR Configuration Management procedures.

When an Exemption or Equivalency is determined to not be necessary, the alternative, waiver, performance-based approach or similar method shall be documented in the project record for future reference.

12.2.6 IMPORTANT BUILDINGS

The term "important buildings" is used throughout this document and is intended to encompass those buildings that meet one or more criteria in Section 12.2.1, have been identified as important to emergency response capabilities or important to site operation and recovery efforts after large-scale events. These buildings shall include the following. Additional buildings may be identified by the SPR DOE Emergency Preparedness Manager or designee(s) based on individual site needs and emergency response considerations. Note that weather enclosures for equipment are not included here but are otherwise addressed in Section 12.4.3.

a. Permanent and temporary / portable occupied buildings.

b. Building containing main control room for the site

c. Building containing main control room for specific operation (e.g., Degasification Plant)

d. Buildings designated as defend-in-place locations for large-scale fire and explosion conditions

e. Buildings containing records, including design and engineering information, when such records are not duplicated at a remote off-site location

f. Electrical buildings which do not have full redundancy for attached safety or recovery systems

g. Security entry portals/gates

h. Central alarm stations

i. Fire apparatus storage building (or portions of such buildings)

j. Warehouses or maintenance buildings containing equipment or parts that cannot otherwise be obtained in 8 hours or less

12.3 SITE DESIGN CRITERIA

12.3.1 GENERAL

The design of all new sites or modification of existing sites, shall be in accordance with Chapters 2, 5, 8 and 13 of this Level III Design Criteria. In addition, the following fire protection, life safety, hazardous materials and emergency response considerations shall be incorporated into new or modified site plans. Existing facilities shall consider these same items during modification of the site, addition of crude oil well caverns, construction of new buildings and similar expansion of facilities.

a. Turning radii for fire and emergency response apparatus, including pick-up trucks with trailers and other specialty equipment.

b. Bridges internal to site boundaries shall be designed to carry the largest fire apparatus from surrounding jurisdictions that may respond to the site or the largest vehicle incorporated into site emergency plans that might traverse the bridge (e.g., truck-hauled, trailer-mounted pumps, generator systems, electrical transformers, etc.) whichever is greater. The width and clear height of the bridge shall be consistent with roadway requirements in Chapter 2, and any turning radius as per Item a above.

c. Bridges external to the site shall be evaluated to ensure evacuation routes can be maintained (i.e., will carry the load, speed and frequency of evacuating vehicles). The bridges shall also be evaluated against vehicles identified in site emergency plans (e.g., truck-hauled, trailer-mounted pumps, generator systems, electrical transformers, etc.) to determine if any do not or no longer support such vehicles.

d. Location of fences or similar obstructions such that egress can be accommodated, entry by responders can be affected and obstruction to firefighting equipment and water/foam spray does not occur. (See Section 12.3.2 for more information.)

e. Exposure distances between opposing buildings and hazards, particularly crude oil containing systems to other equipment and buildings. (See Section 12.3.3 for more information.)

f. Establishment of or maintenance of wildland fire perimeters and protections.

g. Small buildings or storage rooms intended for hazardous materials storage, designed in accordance with the IBC and NFPA 400, along with other codes and standards consistent with the stored materials.

h. Needed enclosures or buildings necessary to provide freeze-protection for aboveground fire protection equipment including, but not limited to, electronics for fire detection/alarm systems, water-based fire suppression systems, gaseous or chemical agent systems and extinguishers and electronics for gas detection systems.

i. Provision for a building, or portion thereof, to house primary response equipment and apparatus for the ERT (fire station).

12.3.2 SITE FENCES AND GATES

a. Fencing and gates surrounding specific equipment or the site shall be coordinated with emergency response planning for the particular equipment, area or site bounded.

b. Fences shall be coordinated with other equipment and structures to ensure access by emergency responders and to avoid obstruction of installed fire suppression systems (automatic and manual). This requirement shall consider at a minimum, but not be limited to:
   1) Access to fire hydrants, monitor nozzles and combination units
   2) Access to fire department connections
   3) Access to fire system manual activation means (e.g., manual pull stations, trim valves on water-based system risers, manual valves on gaseous agent release heads, etc.)
   4) Access to field fire alarm control panels
   5) Proximity to pipe and electrical racks/bridges/tunnels
   6) Proximity to buildings and other structures
   7) Relationship to containment systems, berms, and similar structures
   8) Relationship to electrically classified areas

c. A minimum of two remote points of egress shall be provided for each gated area, with additional gates at the discretion of the SPR DOE Emergency Preparedness Manager or designee(s). The egress gates shall be provided with listed exit hardware intended for the style of gate and designed for the weather conditions and electrical classification applicable to the area.

d. A minimum of one vehicle gate shall be provided for each gated area, with additional gates at the discretion of the SPR DOE Emergency Preparedness Manager or designee(s). Vehicle gates shall be a minimum of 16 ft wide and have a clear height of at least 13.5 ft.

12.3.3 FIRE EXPOSURE

Fire exposure for important buildings on site shall be evaluated based on the specific codes and standards applicable to the condition, as follows, except as otherwise directed by the SPR DOE Emergency Preparedness Manager or designee(s):

a. Building-to-building fire exposures for new or significantly renovated important buildings shall be designed to Chapter 6 of the IBC; NFPA

80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures* and any other driver documents specific to that building or occupancy (e.g., NFPA 30, NFPA 75, NFPA 400, etc.).

b. Building-to-building fire exposures for existing important buildings shall follow the building code of record, the record edition of NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures* and the record editions of any other driver documents specific to that building or occupancy (e.g., NFPA 30, NFPA 75, NFPA 400, etc.).

c. Building-to-building fire exposures for all other buildings shall follow the requirements of:
   1) Chapter 6 of the IBC (new buildings or modified as identified in accordance with Section 12.2.2)
   2) The building code of record (existing buildings)
   3) DOE-STD-1066-2016 and ASL5480.18 (new or existing temporary buildings)

d. Important buildings shall not be built above or in the natural drain path of buried or exposed pipelines containing flammable products (i.e., crude oil or crude oil contaminated liquids) whose working pressure exceeds 50 psig, oil well caverns, crude oil pump pad/containment or other similar equipment.

e. In addition to Item d, important buildings especially occupied buildings shall not be constructed in proximity to crude oil containing equipment or pipelines including, but not limited to, crude oil storage or slop oil tanks, oil coolers/heat exchangers, high pressure pump pads, piping over 50 psig. The required spacing to exposed building surfaces shall be the lesser of the following:

   1) Per the following SPR-determined radiant heat exposure criteria:
      - Separation distance less than 75 ft – Not permitted
      - Separation distance of 75 ft to 300 ft – Provide:
        - Exposure protection sprinklers per NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*.
        - Fire wall of all non-combustible construction with a fire resistance rating of 2 hours
        - Opening protection (i.e., doors, ducts, etc.) in conformance with their respective NFPA document (primarily NFPA 80,

Standard for Fire Doors and Other Opening Protectives and listing standards) and not exceeding 1,296 in^2.

- Over 300 ft – No exposure protection required.

2) Or if more restrictive, as determined by process or hazard analysis, given construction features of the building, using the applicable API document (or portion thereof) for the structure or hazard (e.g., API Recommended Practice 2021, *Management of Atmospheric Storage Tank Fires*; API Recommended Practice 2001, *Fire Protection in Refineries* for specific topic items like process vessels, oil coolers/heat exchangers; etc.)

f. In addition to Item d, buildings other than important buildings shall be provided with spacing per the associated FM Global Loss Prevention Data Sheet (e.g., FM LPDS 7-88, *Ignitable Liquid Storage Tanks*; FM LPDS 5-4, *Transformers*, etc.) or, if an FM Global Loss Prevention Data Sheet is not available for the specific location or hazard, the applicable NFPA document (e.g., NFPA 30 for flammable/combustible liquids storage and tanks).

g. Crude oil containing structures (e.g., crude oil pump pads, tanks, oil coolers/heat exchanges, etc.) shall be separated from one another as determined by the lesser of:

1) Process or Fire Hazard analysis within the applicable API document (or portion thereof) for the structure or hazard (e.g., API Recommended Practice 2021, *Management of Atmospheric Storage Tank Fires*; API Recommended Practice 2001, *Fire Protection in Refineries* for specific topic items like process vessels, oil coolers/heat exchangers; API 2218, *Fireproofing Practices in Petroleum and Petrochemical Processing Plants*; etc.)
2) The more restrictive prescriptive separation distances per the associated FM Global Loss Prevention Data Sheet (e.g., FM LPDS 7-88, *Ignitable Liquid Storage Tanks*; FM LPDS 5-4, *Transformers*, etc.) or, if an FM Global Loss Prevention Data Sheet is not available for the specific location or hazard, the applicable NFPA document (e.g., NFPA 30 for flammable/combustible liquids storage and tanks).

12.4 BUILDING AND STRUCTURE CONSTRUCTION

12.4.1 IMPORTANT BUILDINGS

a. New important buildings shall be designed as IBC, Type IIB or greater construction. Increased fire resistance rating per Section 12.3.3 shall be included in the construction determination.
   1) New important buildings shall not utilize IBC or NFPA allowances for combustible material in the construction of the building(s), with the exception of the following:
      - Interior finishes for walls and ceilings may be combustible but shall be Class A per ASTM E 84 or equivalent as described in the IBC or NFPA 101.
      - Interior finishes for floors may be combustible, but shall be Class I per NFPA 253, as described in the IBC and NFPA 101.
      - Interior millwork such as doors, door frames, window sashes and window frames.
      - Interior trim.
      - Interior partitions (e.g., for cubicles, separating offices, etc.).
      - Fire resistance rated materials for fireproofing of structural elements (spray-applied fire-resistant materials, mastics/coatings, firestopping caulks, intumescent joint seals, etc.).

b. Existing important buildings, including modifications thereto, shall maintain the construction approach of that building (typically IBC, Type IIIB or greater construction, or comparable based on the code of record).
   1) Existing important buildings shall not utilize IBC or NFPA allowances for combustible material in the construction of the building(s), except for the following:
      - Interior finishes for walls and ceilings may be combustible but shall be Class A per ASTM E 84 or equivalent as described in the IBC or NFPA 101.
      - Interior finishes for floors may be combustible, but shall be Class I per NFPA 253, as described in the IBC and NFPA 101.
      - Interior millwork such as doors, door frames, window sashes and window frames.
      - Interior trim.
      - Interior partitions (e.g., for cubicles, separating offices, etc.).

- Fire resistance rated materials for fireproofing of structural elements (spray-applied fire-resistant materials, mastics/coatings, firestopping caulks, intumescent joint seals, etc.).

12.4.2 OTHER THAN IMPORTANT BUILDINGS

a. New buildings other than important buildings shall be designed as IBC, Type IIIB or greater construction, except where combustible construction (IBC, Type IV or V) is specifically permitted by the SPR DOE Emergency Preparedness Manager or designee(s).
   1) New buildings other than important buildings are permitted to utilize IBC and/or NFPA allowances for combustible material in the construction of new buildings, except as needed to maintain exposure protection per Section 12.3.3.
   2) Interior finishes shall be in accordance with IBC and NFPA 101 requirements.

b. Existing buildings other than important buildings, including modifications thereto, shall maintain the construction approach of that building (typically IBC, Type IIIB or greater construction, or comparable based on the code of record).
   1) Existing buildings other than important buildings are permitted to utilize IBC and/or NFPA allowances for combustible material in modifications, alterations or repairs, except where exposure protection per Section 12.3.3 is determined necessary.
   2) Interior finishes shall be in accordance with IBC and NFPA 101 requirements.

12.4.3 EQUIPMENT-RELATED STRUCTURES

Equipment-related structures include weather protection over pumps, non-occupied equipment enclosures, walkways and stairs for equipment access and similar structures.

a. All new equipment-related structures shall be constructed of noncombustible materials.

b. Existing combustible materials in equipment-related structures shall be replaced with noncombustible materials when such structures are replaced, renovated, or modified.

12.4.4 BUILDINGS OR STRUCTURES USING FOAM-BASED FIRE SUPPRESSION EQUIPMENT

a. Locations where foam-based fire suppression equipment is installed shall be designed with features (e.g., berms, retention ponds, drainage, etc.) to retain the discharged foam for disposal at a later time. If secondary containment for hazardous materials is otherwise provided, the secondary containment may be used to satisfy this requirement.

12.4.5 USE OF COATINGS TO ACHIEVE IMPROVED FIRE PERFORMANCE

a. Coatings to improve fire performance (e.g., flame spread or smoke production reduction, ignition resistance, etc.) shall not be used for new buildings, existing important buildings, or equipment-related structures.

b. Use of coatings to improve fire performance (e.g., flame spread or smoke production reduction, ignition resistance, etc.) may be used in existing buildings other than important buildings when approved by the SPR DOE Emergency Preparedness Manager or designee(s).

12.5 FIRE PROTECTION AND FIRE ALARM SYSTEMS

12.5.1 GENERAL REQUIREMENTS

a. All fire protection and fire alarm system requirements shall be in accordance with DOE-STD-1066-2016 and the requirements of this document.

b. All equipment, parts and materials associated with fire protection and fire alarm systems shall be listed or approved by a nationally recognized testing laboratory [Underwriters Laboratories (UL), FM Global (FM), etc.] for the intended service.

c. All equipment, parts and materials installed in new facilities, modified in existing systems or replaced in existing systems shall be new.

d. When existing systems are modified (e.g., limited changes such as relocating sprinklers for new wall or room construction, addition of one or two new branch lines for new spaces, reconfiguration of sprinkler position to accommodate addition or removal of ceilings, etc.), the code-of-record applicable to the system may be used as the basis for the modification.

e. New systems or additions to existing systems (beyond those described in Section 12.5.1.d) shall be installed in accordance with the latest edition of the codes and standards identified in this document and any associated project specifications.

f. Systems subject to temperature considerations (e.g., freeze-protection for water-based systems, operating-temperature ranges for electronic equipment, maximum operating temperatures for fire pumps, etc.) shall have the temperature considerations addressed during system design or modification. The method for addressing the temperature-related concern shall be in accordance with the requisite NFPA document.

12.5.2 WATER SUPPLY - GENERAL

a. Water supply system shall be designed in accordance with DOE-STD-1066-2016, and as noted in the following section.

   Locations where crude oil is not stored shall be provided with two independent sources of water supply when the maximum possible fire loss (MPFL) exceeds $150 Million.

b. Two independent sources of water supply shall be provided for all sites where crude oil storage occurs.
   1) Supplies shall be designed as redundant to one another.
   2) Supplies shall be located such that they are not subject to a common accident, fire or explosion hazard.
   3) Primary water supply should be potable, unless otherwise approved by the Authority Having Jurisdiction.
   4) Each supply shall be connected to the distribution system by an independent valved lead-in.
   5) Each supply shall be capable of providing a volume that is the greatest of the following, as applicable to individual sites:
      - Six hours for crude oil well cavern and associated exposure protection.
      - Six hours for flammable/combustible liquids storage tanks exceeding 20,000 barrels.

- The greater of two hours or as dictated by API RP 2021, FM LPDS 7-88 and NFPA 30 for flammable/combustible liquids storage tanks up to 20,000 barrels.
- The greater of two hours or as dictated by the requisite API, FM LPDS and/or NFPA document for manual or automatic systems protecting equipment containing crude oil or other flammable/combustible liquid.
- Two hours for all automatic sprinkler systems per DOE-STD-1066-2016.
- In accordance with NFPA 1, *Fire Code* for fire flow requirements for buildings.

c. Water supply systems shall be gridded/looped such that all hazard areas are supplied from at least two separate paths. Piping shall be configured such that individual hazards (e.g., tanks, pump pads, meter pads, etc.) are looped when protection from multiple sides is necessary. Dead-end piping systems with no more than three fire protection devices/systems may be installed when approved by the Emergency Preparedness Manger or designee(s).

d. The design of water supply systems shall assume worst case “dead-end” flow conditions such that valve closures will not adversely affect fire protection system capability.

e. Components of the water supply system shall be designed in accordance with the requisite NFPA document (e.g., NFPA 24 for piping and appurtenances, NFPA 22 for tanks, NFPA 20 for fire pumps, etc.). Material selection shall be based on the most adverse condition related to the various supplies (i.e., corrosiveness, silt suspension, etc.).

f. Post-indicating valves (PIVs) shall be provided for all water supply system sectional valves and valves controlling supply to fire suppression equipment (for monitors, see Section 12.5.8.d). PIVs shall have capability to be locked. PIVs shall not be provided with valve tamper switches (intended to be connected to fire alarm system).

g. New PIVs shall be surrounded, to a distance of two feet from the edge of the PIV, with grading to remove surface water away from the PIV. The grading shall be stabilized with shell, gravel, concrete or similar materials.

h. New PIVs located more than 5 ft from roadways shall be provided with a stable and accessible surface from the adjoining roadway. The surface shall be of concrete, asphalt, or other durable material, or as acceptable to the SPR DOE Emergency Preparedness Manager of designee(s).

i. Existing PIVs in areas subject to flooding shall be evaluated for removal/relocation prior to the equipment being replaced, repaired or modified.

j. Existing PIVs shall be upgraded to meet Sections 12.5.2.h and 12.5.2.i when the equipment is replaced, repaired or modified.

k. PIVs in areas subject to vehicular damage shall be provided with barriers. The barriers shall be designed such that it does not impact the ability to operate the equipment, operate adjoining equipment (hydrants or monitors) or restrict the installation of hoses (for PIVs near hydrants). The type of barrier provided shall be approved by the Emergency Preparedness Manger or designee(s).

12.5.3 WATER SUPPLY – FIRE PUMPS

a. Where a fire pump is provided as the primary source or water supply for a site, one of the following means of improving reliability shall be provided:
   1) Primary/secondary fire pumps
      - The primary fire pump shall be an electric motor-driven type.
      - The secondary fire pump shall be a diesel engine-driven type.
   2) Fire pump with diesel generator
      - The fire pump shall be an electric motor-driven type.
      - The secondary power shall be provided via a fuel-fired (i.e., diesel fuel, natural gas, etc.) engine-driven generator.

12.5.4 WATER SUPPLY – FIRE HYDRANTS

a. Fire hydrants shall be provided in accordance with DOE-STD-1066-2016, NFPA 1, NFPA 24 and hazard-specific driver documents.

b. New fire hydrants shall be surrounded, to a distance of two feet from the edge of the hydrant or PIV, with grading to remove surface water away from the hydrant or PIV. The grading shall be stabilized with shell, gravel, concrete, or similar materials.

c. New fire hydrants located more than 5 ft from roadways shall be provided with a stable and accessible surface from the adjoining roadway. The surface shall be of concrete, asphalt, or other durable material, or as acceptable to the SPR DOE Emergency Preparedness Manager of designee(s).

d. Existing fire hydrants shall be upgraded to meet 12.5.4.b and 12.5.4.c when the equipment is replaced, repaired, or modified.

e. Existing fire hydrants in areas subject to flooding shall be evaluated for removal/relocation prior to the equipment being replaced, repaired, or modified.

f. Fire hydrants in areas subject to vehicular damage shall be provided with barriers. The barriers shall be designed such that it does not impact the ability to operate the equipment or restrict the installation of hoses. The type of barrier provided shall be approved by the Emergency Preparedness Manger or designee(s).

12.5.5 AUTOMATIC SPRINKLER SYSTEMS

a. Automatic sprinkler protection shall be designed and installed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*, DOE-STD-1066-2016, applicable hazard-specific codes and standards and this section.

b. Automatic sprinkler protection shall be provided in all new important buildings. The design shall be based on Ordinary Hazard, Group 1 protection, as a minimum.

c. New buildings other than important buildings shall be provided automatic sprinkler protection as required by the IBC, NFPA 101, applicable hazard-specific codes and standards (e.g., NFPA 30, NFPA 45, NFPA 75, etc.) and other sections of this document (see Sections 12.6 through 12.11).

d. Existing buildings provided with automatic sprinkler protection shall retain such protection unless removal from service is granted by the SPR DOE Emergency Preparedness Manager or designee(s).

e. Where possible, system designs shall incorporate equipment types (i.e., valves, monitoring switches, etc.) and quantities that aid in minimizing inspection, testing and maintenance requirements.

f. Freeze protection in accordance with NFPA 13 shall be provided for all systems.

12.5.6 WATER SPRAY AND FOAM-WATER SPRAY SYSTEMS

a. Water spray and foam-water spray systems shall be designed and installed in accordance with NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*; NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*; FM LPDS 4-1N, *Fixed Water Spray Systems for Fire Protection*; DOE-STD-1066-2016; applicable hazard-specific codes and standards [as identified by the SPR DOE Emergency Preparedness Manager or designee(s)] and this section.

b. Foam-water systems shall be designed assuming the use of 3% aqueous film-forming foam (AFFF).

c. New foam-water systems shall be designed for water-only delivery with automatic activation and foam-water delivery via manual control (after automatic activation) and manual activation (should automatic activation not occur).

d. New foam-water systems shall be designed with a test header to allow for testing of foam solution concentration downstream of the proportioner without discharging foam through system nozzles. The test header shall be sized to be consistent with the design flow and pressure of the system.

e. Existing foam-water systems shall be modified to include a test header to allow for testing of foam solution concentration downstream of the proportioner without discharging foam through system nozzles or a method to demonstrate foam solution concentration shall be incorporated into inspection, testing and maintenance operations. If a test header is used, it shall be sized to be consistent with the design flow and pressure of the system.

f. Where possible, system designs shall incorporate equipment types (i.e., valves, monitoring switches, etc.) and quantities that aid in minimizing inspection, testing and maintenance requirements.

g. Freeze protection in accordance with NFPA 13, NFPA 15 and NFPA 16 shall be provided for all systems.

12.5.7 TANK FOAM SYSTEMS

a. Where tank foam systems are determined to be required by Section 12.9, the systems shall be designed and installed in accordance with NFPA 11, *Standard for Low-, Medium- and High-Expansion Foam*, DOE-STD-1066-2016, API RP 2021, FM 7-88, this section and Section 12.9.

b. Foam-water systems shall be designed assuming the use of 3% aqueous film-forming foam (AFFF).

c. New tank foam systems shall be designed with a test header to allow for testing of foam solution concentration downstream of the proportioner without discharging foam through system chambers. The test header shall be sized to be consistent with the design flow and pressure of the system.

d. Existing foam systems shall be modified to include a test header to allow for testing of foam solution concentration downstream of the proportioner without discharging foam through system chambers or a method to demonstrate foam solution concentration shall be incorporated into inspection, testing and maintenance operations. If a test header is used, it shall be sized to be consistent with the design flow and pressure of the system.

e. Where possible, system designs shall incorporate equipment types (i.e., valves, monitoring switches, etc.) and quantities that aid in minimizing inspection, testing and maintenance requirements.

f. Freeze protection in accordance with NFPA 15 shall be provided for all systems.

12.5.8 MONITOR NOZZLES

a. Monitor nozzles and supporting equipment shall be provided where required by Sections 12.8 through 12.10 and as required by the SPR DOE Emergency Preparedness Manager or designee(s).

b. Monitor nozzles shall be combination straight stream/water spray types.

c. When new monitor nozzles are installed, their location, spacing and coverage shall consider the following:
   1) Benefits of utilizing automatic or semi-automatic operating monitor nozzle systems.
   2) Required flow for the particular hazard, as specified by the hazard-specific code or standard, this document or the Emergency Preparedness Manger or designee(s).
   3) Pressure available at the nozzle, which dictates flow rate and throw distance
   4) Provision of multiple nozzles based on potential weather conditions (particularly wind direction)
   5) Overlapping protection from at least two nozzles
   6) Access routes from roadways to the nozzles
   7) Potential obstructions from surrounding buildings, equipment, racks, fences, and other structures
   8) Access from roadways and relative to hazards protected

d. New monitor nozzles shall be provided with control valves integral to the monitor assembly (e.g., valve in the monitor riser, connection to fire hydrant, etc.), as freeze protection concerns permit.
   1) Where freeze protection concerns do not permit an integral control valve, PIVs shall be provided within 10 ft of the monitor and located such that operation of the PIV does not interfere with the operation of the monitor.
   2) Where vehicle barriers are provided (see Section 12.5.8.j), the placement of the barrier(s) shall be considered with regard to ease of operation of valves and potential interferences between monitors and PIVs.

e. When existing systems or equipment are modified, repaired or replaced, consideration shall be given to improving coverage, flow rate and maintainability as described in Section 12.5.6.b through 12.5.6.d. As a minimum, like-for-like equipment shall be provided.

f. New monitor nozzles shall be surrounded, to a distance of two feet from the edge of the monitor nozzle, with grading to remove surface water away from the nozzle. The grading shall be stabilized with shell, gravel, concrete or similar materials.

g. Where monitor nozzles must be installed on sloped land (e.g., berm sides instead of top, hillside, etc.) or structures, an access (i.e., pathway, stairs, etc.) and platform shall be provided. The platform shall be sized such that the full operating range of the monitor (i.e., rotation and angle) is accommodated.

h. New monitor nozzles located more than 5 feet from roadways shall be provided with a stable and accessible surface from the adjoining roadway. The surface shall be concrete, asphalt or other durable material, or as acceptable to the SPR DOE Emergency Preparedness Manager of designee(s).

i. Existing monitor nozzles shall be upgraded to meet 12.5.8.d through 12.5.8.f when the equipment is replaced, repaired, or modified. Existing monitor nozzles in areas subject to flooding shall be evaluated for removal/relocation prior to the equipment being replaced, repaired, or modified.

j. Monitor nozzles in areas subject to vehicular damage shall be provided with barriers. The barriers shall be designed such that it does not impact the ability to operate the equipment or obstruct spray from the nozzle. The type of barrier provided shall be approved by the Emergency Preparedness Manger or designee(s).

12.5.9 FIRE EXTINGUISHERS

a. Fire extinguishers shall be installed where required by IBC, NFPA 101, hazard-specific codes and standards and this section. The size, rating and distribution of fire extinguishers shall be in accordance with NFPA 10, *Standard on Fire Extinguishers*; FM LPDS 4-5, *Portable Extinguishers* and as dictated by hazard-specific codes and standards.

b. Unless otherwise approved by the SPR DOE Emergency Preparedness Manager or designee(s), the following extinguisher agent types shall be used in the associated areas:

1) Carbon dioxide – Electrical rooms, electrical buildings and locations with electrical equipment operating over 600 V.
2) Clean agent – Computer centers
3) Multipurpose dry chemical – All other locations

c. Where fire extinguisher agents are subject to temperature considerations (high or low), temperature protection shall be provided.

d. The sizing and distribution of extinguishers should attempt to minimize the number of extinguishers in a given building or location balanced against the ability of users to lift and operate the extinguisher.

12.5.10 GASEOUS FIRE EXTINGUISHING SYSTEMS

a. Gaseous fire extinguishing systems shall be designed and installed in accordance with the NFPA standard specific to the agent (e.g., NFPA 12 for carbon dioxide, NFPA 2001 for clean agents, etc.) and manufacturer's requirements. Also see Section 12.6 through 12.7.

b. Gases that pose an asphyxiation hazard under normal design concentrations (e.g., carbon dioxide, nitrogen, argon, etc.) shall not be used in normally occupied area or in spaces subject to frequent entry for surveillance or maintenance unless specifically designed and approved for such use; having both a pre-discharge alarm and time delayed discharge; and after receiving Safety approval of results from an exposure and egress analysis.

c. When new systems are installed at sites having an existing gaseous extinguishing system, the same agent and releasing panel shall be used, when possible, to promote ease of inspection, testing and maintenance.

d. In areas where a fire suppression/extinguishing system is required and the gaseous fire extinguishing system is the only automatic suppression system, a connected reserve supply, configured for convenient switchover, shall be provided.

e. In areas where a fire suppression/extinguishing system is not required and a gaseous fire extinguishing system is being provided as an improved risk feature, a connected reserve shall be provided when required by the SPR DOE Emergency Preparedness Manager or designee(s).

12.5.11 FIRE DETECTION AND ALARM SYSTEMS

a. Fire detection and alarm systems shall be installed where required by DOE-STD-1066-2016, IBC, NFPA 101, hazard-specific codes and standards and this section. Fire detection and alarm systems shall be designed in accordance with NFPA 72, *Fire Alarm and Signaling Code* and hazard-specific codes and standards. Also see Sections 12.6 through 12.11.

b. All new fire alarm systems (short of full site-wide replacement) and modifications to existing systems shall be compatible with existing equipment and operating systems.

c. New and existing important buildings, especially occupied permanent and temporary/portable buildings, shall be provided with smoke detection throughout the building and manual pull stations at all required egress points.

d. New buildings other than important buildings shall be provided with fire detection and alarm systems as required by DOE-STD-1066, IBC, NFPA 101 and hazard-specific codes and standards.

e. Existing buildings other than important buildings shall retain existing smoke detection and manual pull stations unless removal from service is approved by the SPR DOE Emergency Preparedness Manager of designee(s).

f. Where fire suppression/extinguishing systems are installed, the initiating devices associated with the fire suppression/extinguishing system shall be monitored by the site fire detection and alarm systems.

g. Additional initiating or control devices beyond those minimally required by this document shall not be installed unless specifically approved by the SPR DOE Emergency Preparedness Manager or designee(s).

h. The main fire alarm control panel for a site shall be located in the main control room. The control room acts as the supervising station, and off-site monitoring is not required.

i. Where releasing capabilities are necessary for suppression/extinguishing systems, use of the main fire alarm control panel or an existing building-specific fire alarm control panel is preferred.

j. Radio fire alarm panels are acceptable for remote buildings or structures (e.g., raw water intake structures). Radio fire alarm panels shall be listed or approved but need not be listed as fire alarm equipment if the functional requirements of NFPA 72 are met and approval is obtained from the SPR DOE Emergency Preparedness Manager or designee(s). One of the following configurations shall be provided:
   1) Dual, redundant panels
   2) A single panel when three spares are available for local/regional resources and restoration to service can be achieve in 1 hour or less

12.5.12 FIRE RESISTANCE RATED CONSTRUCTION

Fire resistance rated construction requirements vary considerably over the range of fire protection codes and standards, and even vary in the testing standard applicable to a particular situation. Therefore, requirements for fire resistance rated construction shall be in accordance with the codes and standard applicable to the particular situation at hand, as identified by the SPR DOE Emergency Preparedness Manager or designee(s).

Attention shall be given to required opening protectives, including but not limited to dampers (fire, smoke, or fire/smoke, depending on location), doors (fire, smoke, or fire/smoke), penetration firestops and joint seals.

12.5.13 ACCEPTANCE INSPECTION AND TESTING

a. For new systems, an acceptance inspection and test plan shall be developed by the design team (i.e., engineers, contractors, etc.) and submitted to the SPR DOE Emergency Preparedness Manager or designee(s) for review.

   1) The test plan shall encompass each individual system (e.g., sprinklers, fire alarm, fire resistance rated construction, etc.) and include interoperability functional testing (e.g., all functions associated with gaseous fire extinguishing systems or foam-water water spray systems).

2) The plan shall be approved by the SPR DOE Emergency Preparedness Manager or designee(s) prior to start of any acceptance inspection and testing.
3) All acceptance inspections and tests shall be performed by the installing contractor prior to requesting inspection or test by SPR personnel.
4) Execution of the test plan shall be witnessed by the project Fire Protection Engineer, or other engineering disciplines responsible for the systems, and the SPR DOE Emergency Preparedness Manager or designee(s).

b. For modifications to existing systems, the need for a test plan as described in Section 12.5.13.a shall be determined by the Emergency Preparedness Manger or designee(s). Where a test plan is not required, witnessing of inspections and tests by qualified SPR personnel, as determined by the SPR DOE Emergency Preparedness Manager, is still required.

c. All inspections and tests shall be as dictated by the respective NFPA document applicable to the system, manufacturer's requirements and any associated project specifications and drawings.

d. Inspection and test forms incorporated into the applicable NFPA documents (e.g., NFPA 13, NFPA 72, etc.) shall be submitted as part of the overall project closure.

12.6 CONTROL ROOM AND COMPUTER CENTER REQUIREMENTS

12.6.1 GENERAL

a. New main control rooms or computer centers shall be designed in accordance with NFPA 75, *Fire Protection of Information Technology Equipment*.

b. Existing main control rooms or computer centers shall utilize NFPA 75 as the basis for any modifications, upgrades, or renovations.

c. Control rooms or computer centers for specific operations (e.g., Degasification Plant) shall be reviewed by the Emergency Preparedness Manger or designee(s) to determine applicability of NFPA 75.

12.6.2 FIRE SUPPRESSION/EXTINGUISHING SYSTEMS

a. Automatic fire suppression/extinguishing systems shall be provided in new and existing control rooms or computer centers.
   1) Wet-pipe systems are preferred.
   2) Pre-action systems may be installed with the approval of the SPR DOE Emergency Preparedness Manager or designee(s). Where pre-action systems are permitted, they shall be double-interlock type based on initiation of a single smoke detector and loss of air (low pressure switch). Cross-zoning of detection is not permitted.

b. Sub-floor, above-ceiling or other similar concealed space containing combustible items (e.g., cables, hoses, etc.) shall be protected by either automatic sprinklers or a gaseous fire extinguishing system, except when one or more of the following is in place:
   1) All cables are in metallic conduit or raceways
   2) Cables listed for plenum use
   3) Raceway listed for plenum use
   4) Listed equipment power cords up to 15 ft long each
   5) Listed cooling hoses
   6) Installations in accordance with NFPA 70, *National Electrical Code*, Article 300.22(C)

c. Where total-flooding gaseous fire extinguishing systems are installed, the following features shall be provided:
   1) A connected reserve, configured for convenient switchover, in areas where the agent is the only fire suppression/extinguishing system.
   2) Photoelectric smoke detection shall be used as the automatic initiating methodology.
   3) Detectors shall be arranged or programmed for cross-zoning, with the first detector initiating alarm and the second initiating system release.
   4) Manual pull stations initiating both alarm and system release shall be provided at each room exit.
   5) Dead-man/momentary contract abort switches shall be provided at each room exit.
   6) An emergency power shut off device shall be provided at each room exit.
   7) Control relays or other similar equipment shall be provided to shut down ventilation equipment that could adversely affect agent discharge or concentration.

8) Control relays or other similar equipment shall be provided for dampers, door releases and other equipment necessary to provide pressure relieve, enclosure integrity to maintain agent concentration or other design parameter associated with the specific agent.

12.7 ELECTRICAL EQUIPMENT, ROOMS AND BUILDINGS

12.7.1 GENERAL

a. Where possible, electrical equipment, rooms and buildings shall be designed to minimize the need for protection by fire suppression/extinguishing systems.

b. In addition to the IBC and NFPA 101, rooms or buildings containing electrical equipment shall be designed in accordance with NFPA 70, *National Electrical Code* and hazard-specific codes and standards (e.g., FM LPDS 5-4, *Transformers* for interior transformer spaces).

c. Transformers, whether singular or in groups, shall be designed in accordance with FM LPDS 5-4, *Transformers*.

12.7.2 FIRE SUPPRESSION/EXTINGUISHING SYSTEMS

a. Automatic sprinklers shall be installed in electrical rooms, buildings or enclosures under any one of the following conditions:
   1) The electrical equipment is installed in a room/building/enclosure otherwise protected with automatic sprinklers.
   2) Liquid quantities for cooling or lubrication oils are present in equipment in excess of maximum allowable quantities identified in NFPA 400, *Hazardous Materials Code*.
   3) The equipment or room/building/enclosure meets one or more of the loss prevention criteria in Section 12.2.1.
   4) The equipment or room/building/enclosure meets the parameters of an important building in Section 12.2.6.
   5) As required by the IBC and NFPA 101 based on building size and construction type.
   6) In areas where groupings of 15 or more exposed wires and cables (i.e., not in metallic conduit or fire-retardant wrap or coating) with combustible insulation are present and the cables/wires are spaced less than 12 inches apart.

b. Water spray systems shall be provided on transformers when required by FM LPDS 5-4, *Transformers* or otherwise required by the SPR DOE Emergency Preparedness Manager or designee(s). Systems shall be designed in accordance with Section 12.5.6.

c. Gaseous agents shall not be used in lieu of automatic sprinkler protection, unless specifically approved by the SPR DOE Emergency Preparedness Manager or designee(s).

12.7.3 FIRE DETECTION AND ALARM SYSTEMS

a. Fire detection and alarm systems shall be installed in rooms/buildings/enclosures meeting the parameters of an "important building" in Section 12.2.6.

12.8 PUMP STATION, METER PAD AND PROVER PAD REQUIREMENTS

12.8.1 GENERAL

a. The design of pump stations, meter pads and/or prover pads shall be in accordance with this section and augmented by hazard-assessment methods of API RP 2001, *Fire Protection in Refineries*. Alternatives to prescriptive requirements, based on the hazard assessment methods of API RP 2001 or similar documents, may be approved by the SPR DOE Emergency Preparedness Manager or designee(s).

12.8.2 CONSTRUCTION AND LAYOUT

a. In non-corrosive environments, crude oil pumps, meter pads and prover pads shall be located on open pads or below weather protection structures. In corrosive environments, crude oil pumps, meter pads and prover pads may be located within buildings.

b. Where crude oil pumps, meter pads and/or prover pads are within a building, the following requirements shall apply, as a minimum:
   1) The building shall be of noncombustible construction, with primary structural elements fire resistance rated based on the requirements of the IBC, API RP 2001, and API RP 2218.
   2) Building walls shall be designed to be explosion-resistive to a pressure of 100 psf or shall be designed with explosion venting with a minimum ratio of 1 ft^2 per 50 ft^3 of building volume, a maximum

internal release pressure of 20 psf and distribution to as many walls as possible recognizing other construction features and surrounding hazards.

3) When multiple types of equipment are located within the same building, a two-hour fire resistance rated wall with no openings shall be provided to separate each equipment type. The wall shall be explosion resistive (not vented) as indicated in Section 12.8.2.b.2).

c. Where crude oil pumps, meter pads and/or prover pads are provided with a weather protection structure, the following requirements shall apply, as a minimum:
   1) The weather protection structure shall be of noncombustible construction, with primary structural elements fire resistance rated where determined necessary by the IBC, API RP 2001 and API RP 2218.
   2) Any side panels provided on the weather protection structure shall not extend the full height of the wall. The panels shall provide an opening at the lowest elevation that allows natural ventilation into the space and has an area equivalent to the explosion venting requirements of Section 12.8.2.b.2), as a minimum.

d. Where crude oil pumps, meter pads and/or prover pads are located on open pads or beneath weather protection structures, they shall be located, spaced and/or protected in a manner that preserves the loss prevention assumptions in Section 12.2.1. To achieve these goals, one of the following methods shall be applied.
   1) Separation by distance. Separation distances to important buildings, other pads or individual equipment (not on the same pad) that are major to maintaining the loss prevention assumptions and/or other equipment (not on the same pad) containing crude oil or other flammable/combustible liquids (e.g., fuel storage) shall be the greater of 75 ft, as prescribed by Section 12.3.3, per prescriptive requirements in hazard-specific documents or as determined by hazard analysis contained in API RP 2001.
   2) Separation by fire resistance rated construction. Fire resistance rated construction shall have a minimum rating of two hours, have no openings, and be designed to resist local environmental conditions (e.g., precipitation, wind, salt exposure, seismic, etc.). The construction shall extend 4 ft vertically above the pump or meter height and 4 ft horizontally beyond the pump or meter.

3) Protection with water and/or foam. Use of fire suppression systems, sloping/containment of the pad and drainage shall be designed to suppression fire at a single piece of equipment and cool surrounding equipment on the same pad, as well as any exposed equipment that cannot be separated by Items 1 and 2 above.

e. Existing SPR pads are based on an N+1 redundancy configuration and shall be protected accordingly. Future equipment pads (i.e., not extensions of existing pads) may be grouped, subject to the following:
 1) Groups shall be such that loss prevention assumptions of Section 12.2.1 and operating functions are preserved based on redundancy of equipment (e.g., 1-for-1 redundancy, N+1 redundancy, N+X redundancy, etc.).
 2) Equipment shall be segregated by service (e.g., provers or meters associated with differing services).
 3) Each group shall be protected using the methods described in Section 12.8.2.d above.

12.8.3 VENTILATION

a. Where ventilation is utilized to address crude oil vapor accumulation, the system shall be designed with the following features:
 1) Ventilation duct openings intended to move vapors shall be located at a height not exceeding 12 inches from the floor.
 2) Ventilation duct openings shall be distributed as evenly as possible, with attention to low points and drainage locations.
 3) The ventilation rate for the system shall be the greater of 1 cfm/ft^2 of floor area or as needed to reduce vapors to 25% of the lower explosive limit based on statistically-viable equipment and piping failures, as identified in API RP 2001.

12.8.4 SPILL CONTROL/SECONDARY CONTAINMENT

a. Spill control/secondary containment shall be designed to limit damage and reduce potential cleanup costs after a spill or fire.

b. Drainage to the spill control/secondary containment location shall be configured, as best possible, such that exposed pipe and uninvolved equipment are not exposed to potential fire or explosion conditions. The drainage system shall be capable of removing fire protection water plus spilled oil and discharging to a safe location.

c. Enclosed transfer systems (e.g., piping, culverts, covered trenches, etc.) are preferred over open transfer systems (e.g., open trenches, swales, etc.).

d. Where enclosed systems are employed, flame stops or similar equipment shall be provided.

e. Any drain points shall be designed such that the opening or grate is not obstructed by debris or landscaping.

f. The drainage system shall be sized to accommodate the greatest flow of the following:
   1) The flow from a full-diameter pipe failure of the largest crude oil carrying pipe.
   2) The flow from a pipe failure of ¼ the diameter of the largest crude oil carrying pipe plus manual fire suppression water of 1000 gpm over a period of 15 minutes
   3) The flow from a pipe failure of ¼ the diameter of the largest crude oil carrying pipe plus discharge from any associated fire protection system over a period of 15 minutes

g. Secondary containment shall be sized on the flow rate determine in Section 12.8.4.f for a period of two hours.

h. Secondary containment structure(s) shall either be located such that a fire in the containment does not pose a threat to other equipment and buildings, shall be provided with its own fire protection system(s) or shall be provided with fire barriers to minimize exposures to other equipment and buildings.

12.8.5 FIXED FIRE PROTECTION SYSTEMS

Fixed fire protection, as described in this section, is required for all crude oil pumps (excluding blanket oil pumps), meter pads and prover pads.

a. Fire hydrants shall be provided as follows:
   1) Each crude oil pump, meter pad or prover pad shall have two fire hydrants located between 50 and 200 ft from each pump, meter, or prover.

2) An additional fire hydrant shall be located between 50 and 500 ft of each pump, meter, or prover.
3) Where possible, the number of hydrants should be minimized via strategic location to protect multiple pumps, meters or provers.

b. Where oil pumps, meters and/or provers are separated and grouped as described in Sections 12.8.2.d and 12.8.2.e, water-only monitors are acceptable.
   1) Monitors shall be located a minimum of 50 ft from the equipment protected. The maximum distance shall be based on the listing of the nozzle implemented for the protection.
   2) Each pump, meter or prover shall be protected by a minimum of two monitor nozzles.
   3) Monitor nozzles may protect multiple hazards that are adequately separated from one another and where the same nozzle would not be credited for both suppression and cooling of adjacent hazards.

c. Where crude oil pumps, meters and/or provers are not adequately separated and grouped as described in Sections 12.8.2.d and 12.8.2.e, automatic deluge water spray or foam-water spray systems shall be provided, as follows:
   1) Water-only systems may be used when the loss criteria identified in Section 12.2.1 is not met.
   2) Foam-water systems are required when one or more of the loss criteria identified in Section 12.2.1 is met.
   3) Systems shall be designed in accordance with Section 12.5.6 and the following sections.
   4) When a system flow demand exceeds the maximum flow rate of the smallest credited water supply pump (generally 150% of the rating of the smallest fire pump) from Section 12.5.3, the protection shall be split into separate zones. The flow demand of each zone shall not exceed one half of the maximum flow rate of the smallest credited water supply pump.

d. Water-only systems shall provide a minimum density of 0.30 gpm/ft2 on all protected equipment and any exposed piping, valves and equipment within 25 ft that is not protected by some other means (e.g., separate suppression system, passive fire protection, etc.).

e. Foam-water systems shall provide a minimum density of 0.30 gpm/ft2 on all protected equipment, adjacent pad area and any exposed piping, valves and equipment within 25 feet that is not protected by some other means (e.g., separate suppression system, passive fire protection, etc.).

12.9 TANK PROTECTION REQUIREMENTS

12.9.1 GENERAL

a. Tanks and tank farms shall be designed in accordance with Chapters 6 and 10; NFPA 30, *Flammable and Combustible Liquids Code*; FM LPDS 7-88, *Ignitable Liquid Storage Tanks* and API RP 2021, *Management of Atmospheric Storage Tank Fires*.

b. For tanks over 100 ft, only floating roof types shall be utilized.

c. Floating roof tanks with fire protection systems shall be designed such that the floating roof remains buoyant under the combined weight of the roof, anticipated precipitation, foam from fixed fire protection systems and firefighting water.

12.9.2 TANK FIRE PROTECTION SYSTEMS

a. Tank fire protection systems shall meet the requirements of Section 12.5.7 and this section.

b. Floating roof tanks up to 150 ft diameter shall be provided with a manually-supplied fixed foam system.
   1) The system shall be designed in accordance with NFPA 11 for seal-only protection.
   2) The system shall be of the type that rides on the floating roof tank.
   3) The fire department connection shall be located outside the secondary containment for the tank or tank farm.
   4) The fire department connection shall be a minimum of 50 ft from the edge of the secondary containment, unless otherwise approved by the SPR DOE Emergency Preparedness Manager or designee(s).

c. Floating roof tanks over 150 ft diameter shall be provided with a manually-activated fixed foam system, including proportioning system and foam concentrate storage.
   1) The system shall be designed in accordance with NFPA 11 for seal-only protection.
   2) The system shall be of the type that rides on the floating roof tank.

3) Where two or more tanks in the same area are protected, systems shall be co-located to share foam concentrate storage and proportioning equipment.
4) The fire department connection shall be a minimum of 50 ft from the edge of the secondary containment, unless otherwise approved by the SPR DOE Emergency Preparedness Manager or designee(s).

d. Fixed roof tanks up to 100 ft diameter shall be provided with a manually-supplied fixed foam system.
   1) The system shall be designed in accordance with NFPA 11 for full surface protection.
   2) Discharge chambers shall be tank-mounted. Sub-surface injection systems are not allowed.
   3) The fire department connection shall be located outside the secondary containment for the tank or tank farm.
   4) The fire department connection shall be a minimum of 50 ft from the edge of the secondary containment, unless otherwise approved by the SPR DOE Emergency Preparedness Manager or designee(s).

e. Fixed roof tanks over 100 ft diameter shall be provided with a manually-activated fixed foam system, including proportioning system and foam concentrate storage.
   1) The system shall be designed in accordance with NFPA 11 for full surface protection.
   2) Discharge chambers shall be tank-mounted. Sub-surface injection systems are not allowed.
   3) Where two or more tanks in the same area are protected, systems shall be co-located to share foam concentrate storage and proportioning equipment.
   4) The fire department connection shall be a minimum of 50 ft from the edge of the secondary containment, unless otherwise approved by the SPR DOE Emergency Preparedness Manager or designee(s).

12.9.3 MONITOR NOZZLES FOR EXPOSURE PROTECTION

a. Monitor nozzles shall be provided for exposure protection where two or more tanks are located within the same farm or where fire exposures that could cause additional fire spread (i.e., either to the tank from adjacent hazards or to adjacent hazards from the tank) are present.

b. Monitor nozzles shall be provided in accordance with the following:

1) Per Section 12.5.8.
2) Monitors shall be located external to any secondary containment.
3) Monitors shall be located between 50 ft and 200 ft from surfaces to be cooled. Additional distance may be permitted when the nozzle chosen supports the additional distance and the installation is approved by the SPR DOE Emergency Preparedness Manager or designee(s).

12.10 CRUDE OIL CAVERN PROTECTION REQUIREMENTS

12.10.1 SPILL CONTROL/SECONDARY CONTAINMENT

a. Spill control/secondary containment shall be designed in accordance with Chapter 2.

12.10.2 FIRE PROTECTION SYSTEMS

a. Crude oil caverns shall be protected by a combination of fire hydrants and monitor nozzles, in accordance with this section and Sections 12.5.4 and 12.5.8, respectively.

b. The combined flow rate for monitor nozzles and fire hydrants surrounding a crude oil cavern shall be a minimum of 2,000 gpm. The required pressure shall be sufficient to support monitor nozzle flow rate and throw distance.
   1) Existing systems require 100 psi at the hydraulically most remote monitor nozzle, based on existing nozzle types.

c. Monitor nozzles for caverns shall be provided as follows:
   1) A minimum of two shall be provided for each wellhead and associated equipment that could result in oil leaks (piping, valves, flanges, etc.).
   2) The monitor nozzles shall be located and installed such that they are visible and accessible from the cavern floor.
   3) Monitor nozzles shall be located such that fire or weather conditions do not adversely affect use of the minimum number required. Additional monitor nozzles may be necessary to address this concern.
   4) Each monitor nozzle shall have a minimum flow rate of 500 gpm.

d. Fire hydrants for caverns shall be provided as follows:

1) Each cavern shall be provided with three remotely located fire hydrants.
2) Each fire hydrant shall be no more than 250 ft from the edge of the cavern secondary containment.

e. Fire hydrants for remote secondary containment for caverns shall be provided as follows:
   1) Each remote secondary containment shall be provided with two remotely located fire hydrants.
   2) Each fire hydrant shall be no more than 250 ft from the edge of the secondary containment.

12.11 PORTABLE AND TEMPORARY STRUCTURE REQUIREMENTS

12.11.1 GENERAL

a. Portable and temporary structures shall be in accordance with DOE-STD-1066-2016, Appendix C except as modified herein.

b. The term “portable structure” shall include trailers, mobile homes, factory-built office trailers, skid-mounted buildings, lawn buildings and similar relocatable structures or segments of relocatable structures, including semi-trailer vans and cargo and shipping containers utilized for occupiable space (e.g., office, workshops, tool cages, etc.) or the storage of flammable or combustible liquids, gases, or materials, including fuel-powered or fuel-fired equipment, are included.
   1) Structures with a floor area of 20 ft^2 or less are excluded, except for required separation distances in Section 12.11.4.
   2) Plastic or fabric units such as tents, air-supported structures, or prefabricated units with floor areas of 20 ft^2 or less are excluded, except for required separation distances in Section 12.11.4.
   3) Semi-trailer vans and cargo and shipping containers are excluded, with the exception of required separation distances in Section 12.11.4.

12.11.2 APPLICATION

a. This section shall be applicable to all portable and temporary structures at crude oil storage sites, regardless of duration onsite, except for contractor-owned portable and temporary structures located on SPR property for 180 days or less (as determined by the contract period of performance).

b. Contractor-owned portable and temporary structures located on SPR property for 180 days or less (as determined by the contract period of performance) meeting all applicable federal, state, and local construction requirements shall be subject to requirements of this section, as determined necessary and applicable by the SPR DOE Emergency Preparedness Manager or designee(s).

12.11.3 <u>LOCATION</u>

a. Portable and temporary structure location shall be subject to the exposure protection requirements of Section 12.4.

b. Portable and/or temporary structures shall be separated by distance from each other and other structures, as indicated below, or shall be separated via a two-hour fire resistance rated fire wall. Where such separation cannot be achieved, the structures shall be considered as a group.
   1) Portable and temporary structures of IBC, Type IIIB or greater construction shall be separated per the IBC and any hazard-specific code or standard pertinent to its occupancy.
   2) Portable and temporary structures of IBC, Type IV or V construction shall be separated as described in DOE-STD-1066-2016, Appendix C.

c. Portable and temporary structures shall not be located over gas mains, water mains, utility corridors, control valves or manholes serving underground utility systems, unless such utility lines service the structure itself.

d. Portable and temporary structures shall not be located beneath vital power, communication or control lines or under power lines of more than 600 volts such that a fire in the structure could damage the lines.

e. Portable and temporary structures shall not be placed under other vital utilities, such as communication cables and inerting gas lines, unless the re-locatable structure is protected by an automatic fire suppression system.

f. Portable and temporary structures shall be provided with service conductor clearances and disconnects in accordance with NFPA 70.

g. Portable and temporary structures shall be located such that they do not impact life safety features of other buildings, structures, fenced areas or other locations.

h. Portable and temporary structures shall be located to minimize wildland fire hazards and exposures. Where a significant fire risk exists, appropriate fire resistive building materials and/or other methods of protection shall be implemented, at the direction of the Emergency Preparedness Manger or designee(s).

i. Portable or temporary structures located within permanent facilities, including under weather protection structures or equipment structures, shall be acceptable is one of the following approaches is implemented:
   1) The permanent facility is provided with automatic sprinkler protection and the protection is extended into the portable or temporary structure.
   2) In non-sprinklered facilities, a fire hazards analysis demonstrates no significant increase in fire risk to the permanent facility.
   3) In non-sprinklered facilities, a fire suppression/extinguishing system approved by the SPR DOE Emergency Preparedness Manager or designee(s) is provided.

j. See Sections 12.11.4 and 12.11.9 for other factors that influence location.

12.11.4 EMERGENCY ACCESS

a. Portable and temporary structures shall be located such that emergency response vehicles can operate within 100 ft of the structure.

b. Portable and temporary structures shall be located such that they do not obstruct or impede emergency access to other buildings or structures.

c. Security-related fences and any other access barriers shall be designed in a manner that permits emergency access. See Section 12.3.2.

d. Landscaping and similar non-essential obstructions shall not restrict emergency access.

12.11.5 <u>CONSTRUCTION AND DESIGN</u>

a. Portable and temporary structures, other than fabric structures, shall be constructed in accordance with Section 12.4.

b. Fabric structures shall have both a Class A surface burning characteristic and pass Test Method 2 of NFPA 701, *Standard Methods of Fire Tests for Flame Propagation of Textiles and Film*.

c. The combined floor area of grouped portable and/or temporary structures shall not exceed the allowable area specified by the IBC.

d. Life safety features (i.e., required number and locations of exits, travel distances, egress widths, etc.) shall be in accordance with the IBC, NFPA 101 and any applicable hazard-specific code or standard.

e. Elevated portable or temporary buildings shall be provided noncombustible stairs when the elevation to grade exceeds that allowed by the IBC and NFPA 101.

f. Each portable or temporary structure, when set up on SPR property, shall be mounted at grade or shall be provided with noncombustible skirting to enclose the below-floor area to prevent the accumulation of wind-blown debris and the storage of combustible and flammable materials.
   1) Solid metal panels or noncombustible fence material (such as "chicken wire") with a maximum wire mesh of 1 inch by 2 inches shall be used for the skirting.
   2) The skirting shall be fastened to the structure and as needed, to noncombustible supports at grade.
   3) The skirting and attachments shall be designed to resist removal by wind.

12.11.6 <u>OCCUPANCY AND USE</u>

a. Sleeping quarters and similar configurations (beds, futons, convertible couches, etc.) shall not be permitted unless the portable or temporary building is designed and approved as a sleeping facility and has a specific sleeping area meeting appropriate DOE and NFPA criteria, including the provision of smoke alarms.

b. Portable or temporary structures shall not be used for chemical laboratories.

c. Portable or temporary structures used to house information technology equipment vital to management, operation and maintenance of the site shall be in accordance with Section 12.6.
    1) This requirement is not intended to preclude the use of personal computers or mainframe terminals interfaced as user terminals to such systems.

d. Portable or temporary structures used to store program-critical components or spares shall be in accordance with requirements for important buildings in this document.

12.11.7 MARKING

a. To aid emergency response, all portable and temporary structures shall be marked with a site-consistent number, assigned by the Site Director or designee, in a color that contrasts with the background or structure color. The numbers will be at least 6 inches high and two inches wide (except for the number 1), with the principal strokes of the numbers at least ¾ inch wide.
b. Exceptions to the marking requirement include approved portable or temporary structures installed inside permanent buildings or facilities and approved portable or temporary structures used by contractors and subcontractors when a company sign or logo is attached to the structure on the road approach side or end.

12.11.8 MECHANICAL AND ELECTRICAL SYSTEMS

a. Heating and cooling systems and equipment for SPR-owned or SPR-operated facilities shall be listed or labeled and installed in accordance with their listed design and other appropriate standards. Where oil, methane or liquid petroleum gas is used, a readily accessible, approved manual shutoff valve will be installed on the structure's exterior. The shutoff valve will be identified with a sign that states "Emergency Gas Shutoff" in letters at least 1 inch high, with yellow symbol on red background or red symbol on yellow background.

b. Electrical wiring and equipment shall comply with NFPA 70, *National Electrical Code*.

c. Portable heat producing devices within portable and temporary structures, and their use, shall be in accordance with ASL5480.18, *Fire Protection Manual*.

12.11.9 FIRE PROTECTION AND FIRE ALARM SYSTEMS

a. Automatic sprinkler protection shall be provided when one or more of the following is met:
   1) When any single portable or temporary structure exceeds 5,000 ft^2.
   2) When any group of portable and/or temporary structures (see Section 12.11.3.b), including any interconnecting walkways or decks constructed of combustible materials, exceeds 5,000 ft^2.
   3) As required by Section 12.5.3.
   4) As required by Section 12.6 or Section 12.7.
   5) As required by any hazard-specific document applicable to the use of the structure.

b. Where automatic sprinkler protection required by Section 12.11.9 cannot be provided, due to inadequate water supply or other circumstance, alternative fire protection systems shall be permitted when approved by the SPR DOE Emergency Preparedness Manager or designee(s).

c. Portable and temporary buildings shall be located relative to fire hydrants as follows:
   1) If the portable or temporary building is occupied or considered an important building based on Section 12.2.6, fire hydrants shall be provided per Section 12.5.4.
   2) For all other portable or temporary buildings:
      - At least one fire hydrant is located near the structure, with the hydrant no closer than 40 ft and no further than 300 ft.
      - A second fire hydrant shall be located no closer than 40 ft and no further than 500 ft.

d. Fire extinguishers shall be provided in accordance with Section 12.5.9.

e. Fire detection and alarm systems shall be provided in accordance with Section 12.5.11.

CHAPTER 13

PHYSICAL SECURITY SYSTEM

13.1 PURPOSE

This chapter establishes minimum standards of design criteria for the Strategic Petroleum Reserve (SPR) physical security system as well as policy governing the levels of protection at various security areas. The criteria specified herein are based on Department of Energy (DOE) Order 473.3A Protection Program Operations and the SPR Site Security Plan (SSP).

13.1.1 PRE-EXISTING CONDITIONS

Pre-existing site security conditions less stringent than those specified herein are not required to be upgraded.

13.2 FACILITY CLASS

The DOE Washington Office has identified the SPR operational facilities as a protection level (PL) 5 - 8 facility in accordance with the Design Basis Threat (DBT) and definitions provided in DOE Order 473.3A and the SSP.

13.3 GENERAL DESIGN REQUIREMENTS

Refer to the Multisite Security Functional Specification, MS-PP-910-001 for additional security system operational philosophy and implementation.

13.3.1 SECURITY SYSTEMS DESIGNS

The design of the physical security intrusion system must provide perimeter protection, timely detection and assessment, and internal protection commensurate with the operational criticality of perceived targets. Security system designs shall be technically and economically sound for the facility being protected. Differences in geography, site construction, and varying site drawdown objectives necessitate unique security designs for each site. [redacted]

[redacted] Cost considerations of the physical security system shall include not only the original investment, but also annual and 20-year operating cost and the cost of the related protection force.

13.3.1.1 **Integration with Other Systems.** The security system shall not be integrated into other facility monitoring system(s) in any manner that might lower the system reliability or availability.

13.3.2 USE OF OFF-THE-SHELF EQUIPMENT

To the extent possible without compromising system performance, maximum use shall be made of "off-the-shelf" equipment. The design shall employ equipment and repair parts available from the General Services Administration (GSA) catalog of Physical Security Systems. Where the designer elects to employ equipment similar to that available from the GSA, the technical rationale for not using GSA equipment shall be provided for DOE review and disposition.

SPR Cyber Security shall be included in the planning and purchase of new physical security systems and/or components to ensure compatibility and to prevent any Cyber Security Threats to the SPR network.

13.4 SECURITY AREA DESIGNATIONS

The principal security terms discussed in this chapter are the following:

- Site Property Boundary
- [redacted]
- Property Protection Area
- Control Area
- [redacted]
- Security Facility

13.4.1 AREA DEFINITIONS

13.4.1.1 **Site Property Boundary.** The legal, physical boundaries of the land owned by the DOE.

[redacted]

13.4.1.3 **Property Protection Area.** A Property Protection Area is a non-alarmed area that is physically and legally delineated by the perimeter of the site, or other parcels of DOE property where protection is required. Throughout the SPR, existing site security perimeters and the New Orleans administrative buildings constitute the Property Protection Area boundaries. Other areas include the brine disposal wells located at Bayou Choctaw and West Hackberry, and off-site pipeline valve stations.

13.4.1.4 **Control Area.** A Control Area is any area, building, or structure that is not a Drawdown Critical Area, but requires limited entry for protection of SPR personnel and resources. This includes resources that directly support but are not essential to drawdown.

A Control Area security designation is also assigned to areas approved to receive, use, or store classified matter. Control Areas in the SPR are contained within buildings and resources outside buildings. Control areas may be protected by Intrusion Detection System.

[redacted]

[redacted]

[redacted]

13.5 SPECIFIC REQUIREMENTS

The following defines the minimum acceptable security system requirements associated with the previously defined security areas.

Site specific conditions may require deviation from the following requirements. Procedures for submitting requests for security deviations are found in DOE Order 473.3A, Protection Program Operations.

13.5.1 SITE PROPERTY BOUNDARY

As a minimum, this boundary shall be posted with "NO TRESPASSING" signs, installed at each entry point, fence corner and a minimum of every 100 feet along the boundary. Where fencing is not used to mark DOE Property, warning signs shall be installed at 50-foot intervals. Where the site boundary traverses marshland, the signs may be spaced at 150 feet if another internal barrier is also posted. At locations where the Site Property Boundary and the Security Perimeter coincide, the "NO TRESPASSING" signs shall be posted in accordance with the requirements of this chapter. The density and configuration of signs will be so as to provide assurance that during the daylight hours at least one sign would be readable to an individual entering a site or transiting a marked boundary.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

13.5.3 PROPERTY PROTECTION AREA

The Property Protection Area shall be established as a result of experience, reason, or analysis having confirmed that unless special property protection controls are employed, extensive theft of or damage to SPR property is likely to occur. Theft of or damage to such property could impact national security, SPR program continuity, or protection of public health or safety. The Property Protection Area shall be provided with security protection such as:

- Clearly defined perimeter barriers and clear zone
- Personnel and vehicle access controls
- Personnel identification system
- Signs

13.5.4 CONTROL AREA

A Control Area is an area that requires access controls, either procedural or physical or containing critical must operate equipment. Controlled Areas include, as a minimum, rooms or buildings housing weapons, explosives, classified matter, central alarm stations (CAS), operational control, and buildings housing pumps required during drawdown. Controlled Areas in the SPR are (1) those resources outside buildings (external) and (2) those resources contained within buildings (internal).

13.5.4.1 **External Control Area.** Control areas external to buildings shall be secured by such appropriate control, deterrence, and detection systems deemed necessary for protection. They include:

- Barrier(s)
  - Fence
  - Wall
  - Clear zone
  - Cabinet
- Secondary Gate(s)
- Key-lock Access
- Intrusion Detection System (several different types of security alarm systems may be combined to provide one level of protection)
- Lighting
- Signs (as specified in this chapter)

13.5.4.2 **Internal Control Area.** Control areas inside of buildings shall be secured by such appropriate control, deterrence, detection, and assessment systems deemed necessary for protection. They include:

- Walls
- Doors

- Cabinets
- Key-lock Access
- Intrusion Detection System (One level minimum)
- Intrusion Assessment System (Closed Circuit Television Cameras)
- Lighting
- Signs (as specified in this chapter)

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

- [redacted]

13.5.6 WAREHOUSE FACILITIES

13.5.6.1 **SPR Warehouse**. Permanent property storage warehouse facilities, such as the SPR New Orleans Warehouse, will be located within a Security Perimeter. [redacted]

13.5.6.2 **Off-site Warehouses.** Off-site warehouses containing consolidated critical components will be equipped with at least two levels of alarms (one internal along with one external). [redacted]

13.5.7 PARKING

Technical design criteria for parking lots, internal or external to the site, may be found in Chapter 2, Site Development. External parking lots for privately owned vehicles shall be provided adjacent to the main site entry point. Fencing, property acquisition, and other design considerations are specified elsewhere in these criteria.

13.5.8 WEAPONS CLEARING AREAS AND FACILITIES

Weapons clearing areas may be internal or external. They will be constructed and located in a manner that properly protects and ensures the safety of all personnel. Weapons clearing facility designs and locations will be approved by the Protection and Physical Security Department.

13.5.8.1 **<u>Weapons Clearing Chambers (External)</u>.** External weapons clearing chambers will be covered, with at least 3 walls, to ensure that wind/weather does not affect a safe loading/unloading process. The individual supervising the loading/unloading must be able to stand behind and to one side of the individual loading/unloading the weapon without getting wet. The area will have sufficient lighting (min. 1 ft. candle). The area will have shelves positioned to either side of the clearing area to allow the officers to free their hands for the loading and unloading of weapons. A clearing chamber (barrel) will be centered between the shelves. The chamber (barrel) will be capable of containing a 7.62 caliber round fired accidentally. The pipe section will be of a diameter sufficient to accept standard shotguns and rifles as well as pistols (6-inch minimum). The receptacle end of the containment pipe will be mounted approximately 3 feet high and have at least 2-foot clearance between the center of the pipe opening and the shelves.

13.5.8.2 **<u>Weapons Clearing Area (Internal)</u>.** An internal weapons clearing area may be located within a permanent facility. This area will contain facilities for safe clearing of weapons. An individual supervising weapons loading or unloading must be able to stand behind and to one side of the individual loading or unloading the weapon. The area will have sufficient lighting (min. 1 ft. candle). The area will have shelves positioned to either side of the clearing area to allow the officers to free their hands for the loading and unloading of weapons. A clearing chamber will be centered between the shelves. The chamber (barrel) will be capable of containing a 7.62 caliber round fired accidentally. The pipe section will be of a diameter sufficient to accept standard shotguns and rifles as well as pistols. The receptacle end of the containment pipe will be mounted approximately 3 feet high and have at least 2-foot clearance between the center of the pipe opening and the shelves.

13.6 MAIN GATE

A perimeter gate on the main access route to each site shall be designated the site main gate. The Site Main Gate Guard Station shall be designated, equipped, and located at this point. This facility shall be designed to control personnel and vehicle entry to the site.

The station shall also be designed to accommodate the following:

- Physical obstacles (jersey bouncers) strategically placed around the main gate to provide cover and concealment for Entry Control Officers.

- Motor driven main gate with manual override, operable from both within and outside the Guard Station.

- Direct Line communications [redacted] to the CAS and Operations Control Room (OCR), radio communications, working space for two people, storage for badge stock, and appropriate climate controls.

- Emergency power for lighting, communications, Closed Circuit Television (CCTV), and gate operation.

- A vehicle traffic barricade located interior to the motor driven gate at a distance sufficient to allow standard size vehicles (under 26 feet) to stop between the barrier and the gate shall be located at all site main gates. [redacted]

- A pan/tilt/zoom CCTV camera positioned to monitor main gate and access route activities.

- See section on lighting for specific lighting criteria.

13.7 PERIMETER GATES

The barrier shall have a minimum number of vehicular and pedestrian gates consistent with operational requirements. Gates shall also be installed to avoid trapping personnel inside hazardous areas and for access to fire protection equipment. These gates shall be structurally comparable, provide the same or greater resistance to penetration as the adjacent fence, and be designed so that entering and exiting traffic shall be under the supervision of the security force.

[redacted] Gates shall be equipped with vertical arm brackets mounted at the top of the gate. Such brackets shall be 18 inches long with at least three strands of 12-gauge barbed wire on 5-inch centers. All gates shall be equipped with a barbed wire topping and a chain and padlock, or equivalent locking device.

Gate(s) in fences surrounding Property Protection Areas (other than the Main Gate), Critical Areas, and External Controlled Areas shall be kept to a minimum number consistent with operational and safe egress requirements. The gates shall provide the same resistance to penetration as the adjacent fence and shall be subject to the same [redacted] coverage as the fence. In addition, each gate shall be equipped with tamper resistant detectors that will automatically alarm when the gates are opened. Normal entry gates shall be equipped with chains and padlocks or equivalent. Crash-out gates shall be equipped with panic latching devices operable from the inside only and shall meet the requirements of these criteria. Provisions shall be made to prevent intruders from reaching or projecting an object to open the gate from the outside of the area.

13.8 BARRIER

A physical obstacle around security areas to deter or impede unauthorized access that shall meet the requirements in the DOE 470 series with the following exception for fences: (1) outer clear zones shall be a minimum of 10 feet, (2) ground clearance shall be designed and installed to ground level and maintained to within 4 inches, and (3) drawings and specifications shall call out soil stabilization measures.

13.8.1 BARRIER SPECIFICATIONS

1. **Perimeter Fencing**

   (a) **Fabric**. The fence fabric as a minimum, shall be 11-gauge, 2 x 2 mesh woven galvanized before weave wire.

   (b) **Mounting**. The fence shall be mounted on metal posts of appropriate height with additional bracing, as necessary, at corners and gate openings. A minimum of four galvanized tie-wires equal in gauge to fencing shall be used to secure fence fabric to posts and other structural members. Posts, bracing, and other structural members shall be located on the inside of the fence, except taut-wire fencing.

(c) **Height**. The minimum height of the mesh fabric above the ground surface shall be 7 feet.

(d) **Topping**. As a minimum, an 18-inch-long topping (normally an outrigger) with three strands of galvanized barbed wire equal in gauge to the fence shall be installed. The wire shall be installed a minimum of 4 inches above the fabric and spaced less than 6 inches apart. The barbs will be 14-gauge, 2 points.

(e) **Reinforcing Wire**. A rail or taut reinforcing wire shall be installed at the fence top and bottom for stabilization of the fence fabric. It shall be firmly attached to the fence fabric.

(f) **Anchoring**. The bottom of the fence fabric shall be installed to ground level and maintained at 2 inches when protected by Intrusion Detection System and 4 inches for areas not protected by Intrusion Detection System. The bottom of the fence fabric shall be anchored to prevent intruders from lifting the fabric to create an opening more than 5 inches in height. Horizontal bottom rails, concrete curbs or sills, sheet piling, piping or other measures may be used for this purpose.

(g) **Stabilization**. Surfaces will be stabilized in areas where loose sand, shifting soils, or surface waters may cause erosion and thereby assist an intruder in penetrating the area. If surface stabilization is not possible, or is impracticable, concrete curbs or sills or other similar types of anchoring devices, extending below ground level, shall be provided.

(h) **Clear Zone**. An area adjacent to the barrier which is cleared of all equipment, vegetation, etc. which might afford concealment or aid in circumventing the barrier. Any items that must be erected within a clear zone due to operational requirement must be equipped with devices to prevent climbing (i.e., fire monitors, light poles, etc.). Clear zones are required outside and inside any barrier. (Width should be 10 feet minimum.)

(i) Penetrations through fences may be necessary to accommodate operational requirements. Openings greater than 96 square inches or more with the least dimension greater than 6.0 inches shall be protected by welded bar grills. The height of the fence shall be raised above the penetration to obtain the same unobstructed fence height that would exist without the penetration.

2. **Critical Area Fences**

(a) **Fabric**. Fence shall be either a taut-wire sensor fence or chain link if a separate sensor is employed. Taut-wire systems will comply with high security standards as described in manufacturer's manuals. Maximum spacing between strands will be 6 inches. Chain link fence shall be galvanized before weave steel, aluminized, or plastic coated woven-steel 2-inch square mesh, 11-gauge diameter wire and shall conform to Appendix A. Fence fabric, where fence sensor systems are installed, shall be tight to prevent vibrations from setting off false alarms. All 4 corners of the signs shall be attached to the fence in a taut manner.

(b) **Mountings**. The fence fabric shall be mounted on metal posts of appropriate height set in concrete with additional bracing, as necessary, at corners and gate openings. In areas where metal posts are not available, reinforced concrete posts shall be substituted. Posts, bracing, and other structural members shall be located on the inside of the fence fabric (except for taut-wire installations). A minimum of four galvanized tie-wires equal in gauge to fencing shall be used to secure the fence fabric to posts and other structural members.

(c) **Height, topping, reinforcing wire, anchoring, and stabilization**. Height, topping, reinforcing wire, anchoring, and stabilization shall meet the requirements of this chapter for perimeter fencing.

3. **Gates**. As described in this chapter.

4. **Drainage**. Drainage structures and water passages penetrating the barrier shall be barred to form obstacles to unauthorized entry equivalent to the fence itself. Openings to drainage structures having a cross-sectional area greater than 96 square inches or more with the least dimension greater than 6.0 inches shall be protected by securely fastened welded bar grills. As an alternative, drainage structures may be constructed of multiple pipes, each pipe having a diameter of 10 inches or less. Multiple pipes of this diameter may also be placed and secured in the "in-flow" end of a drainage culvert to prevent intrusion into the area.

5. **Building Walls**. Building walls may be incorporated into the barrier system provided they offer protection against intrusion equivalent to that of the perimeter barrier and are subjected to visual observation. Where a fence adjoins a building wall, the fence shall extend to within 2 inches of the building wall. When a structure is utilized in conjunction with a fence to form part of a perimeter barrier, the height of the fence shall be increased sufficiently where it adjoins the structure to preclude use of the structure to gain access. When a building wall is 18 feet or less in height and forms part of the barrier, a top guard (barbed wire) will be used along the outside coping to deny access to the roof. Any windows in walls below 18 feet shall be covered with steel bars or mesh.

6. **Fence Lines and Roadways**. Where practicable, at least 10 feet (preferably 20-feet) of clearance shall be maintained between fence lines and adjacent interior or exterior areas which might afford concealment for potential intruders.

7. **Lighting**.

   (a) **General**. The following sections extracted from DOE Orders are applicable. The site [redacted] as well as the perimeter of [redacted] and [redacted] shall be lighted. The level of lighting of a security perimeter shall be appropriate to satisfy the requirements of the Intrusion Assessment System employed. Factors to be considered by the designer shall include the following:

(1) **Area Lighting**. The perimeter of areas protected by Intrusion Detection System and assessed by CCTV shall be lighted to a minimum of 0.5 foot-candles measured 12 inches above ground at the outer edge of the outer clear zone. Main gate lighting shall permit identification and vehicle inspection. Lighting provided at manned entry control posts must provide illumination of at least 2.0 foot-candles intensity measured 6 inches above ground along the traffic center line and for 25 feet outward.

(2) **Application**. The protective lighting system shall be selected to satisfy the installation needs and peculiarities. The system must be compatible with the terrain, vegetation, building distribution of the area being protected, and additionally, shall be compatible with the spectrum requirements of the CCTV, if used.

(3) **Characteristics**. The lamp intensities and spectral and physical characteristics shall be selected for best compatibility with the site requirements. The Illuminating Engineering Society (IES) Lighting Handbook shall be used for technical reference in determination of lighting characteristics. Light glare shall be kept to a minimum in those situations where it would impede effective operations of protective force personnel, interfere with rail, highway, or navigable water traffic or be objectionable to occupants of adjacent properties. Light sources on perimeters shall be so located that illumination is directed, whenever possible, outward. There should be relative darkness along patrol routes and at fixed posts other than pedestrian and vehicular entrances.

8. **Locks**. Unoccupied facilities shall be locked. Key locks in doors shall be resistant to picking and jimmying, and combination locks shall be resistant to manipulation. Padlocks shall be of sturdy construction and resistant to opening by picking, rapping, forcing, or the use of shims or similar techniques.

13.8.2 SIGNS

a. Site Property Boundary and/or Security Perimeter signs shall state "NO TRESPASSING" and shall be posted at each entrance, corner and a minimum of every 100 feet along the boundary and/or perimeter (as described in this chapter).

b. Alarm area signs shall state "WARNING: THIS AREA PROTECTED BY INTRUSION DETECTION SYSTEM. ALARMS WILL INITIATE ARMED PROTECTION FORCE RESPONSE" and shall be posted at the perimeter of property protection areas that are protected by Intrusion Detection System. Interior areas protected by Intrusion Detection System require signs only at the entrance to the area. These signs will be burnt orange in color. All wordings on the sign will be a minimum of one-half inch except the word "Warning" which will be a minimum of one- and one-half inches. Where posted with "No Trespassing" signs, the two may be combined or placed adjacent to each other.

13.9 CENTRAL ALARM STATION

This function shall be located internal to the site. The CAS shall be a hardened facility to protect against a minimum of 7.62 x 51 NATO caliber small arms fire. The stations shall be located within or established as a controlled area and be constantly attended. The CAS may be a separate building or a hardened facility in an existing building. Access to the CAS shall be controlled by an electric locking device with manual override so the controllers can control entry without leaving their work position. Admittance shall be restricted to persons requiring access in the performance of official duties on a need-to-know basis. Visual and audible communication between the controller and person(s) requesting entry/exit shall be provided. Additionally, the CAS shall incorporate the following:

Communications: Four radio channels shall be available at the CAS, including the primary radio base station, backup communications, duress system, and direct line communications to fixed protection force posts, control room, and manned alarmed areas. Provision shall be made for radio/telephone communications with local law enforcement.

A CAS Controller Console shall be provided to monitor Intrusion Detection and Assessment Systems visual displays and audible alarms.

Wall space shall be provided for site and area plotting maps and status boards.

The CAS shall be on emergency generator power, as well as an UPS to provide continuous operations of emergency lighting, communications, Intrusion Detection System, and IAS (CCTV) in the event of loss of commercial power. The UPS batteries shall be sized to carry full loading for a minimum of 60 minutes as noted in section 5.3.3 EMERGENCY POWER.

13.10 OPERATIONS CONTROL ROOMS

Each OCR shall contain a minimum number of entrances. Keypads with numerical codes will be used to permit entry by authorized personnel. Additionally, doors shall be electrically locked and entry controls will include visual and audible communication with the operator. This permits the Control Room Operator to permit entry by authorized personnel who have not been issued keypad code numbers. The OCR shall have a transmit and receive duress system with the main gate and CAS. A fixed CCTV camera shall be installed to monitor avenues of approach to the primary OCR Entry Door.

13.11 INTRUSION DETECTION SYSTEM

An Intrusion Detection System shall be provided to augment security force protection of site perimeter, drawdown critical and controlled areas only. The system shall be designed to detect and alarm all attempts of unauthorized entry into these areas. All unmanned exits from security areas shall be equipped with Intrusion Detection Systems.

Design of the Intrusion Detection System shall provide for systems which are fail-safe in operation, offer maximum detection capability, and limit the number of nuisance/false alarms which occur as a result of events such as equipment malfunction, environmental effects, or detection of nuisance objects. The Intrusion Detection System shall continuously operate during power outages for four hours on batteries and be so configured that intrusion alarms are not initiated as a result of loss of normal power, operation of backup power, or restoration of normal power. Those that are not on the emergency generator supply will have a minimum of [redacted] battery power. All power source transfers shall occur automatically. Both visual and audible alarms shall be provided at the CAS. Systems installed after June 1, 1989, shall include the incorporation of interactive video by a minimum of menu-selected responses.

Transmission lines from control units to monitor panels that are open or accessible to tampering shall be electrically supervised. Power for intrusion detection portions of the security system shall be from non-interruptible power sources. Batteries or battery/inverter systems that automatically transfer on power loss without yielding false alarms shall be used for this function. As a minimum, an [redacted] back-up power source shall be provided for each control unit and monitor panel.

Application and selection of Intrusion Detection System systems shall ensure compatibility between the equipment, environment, and site characteristics. Environmental features such as heat, humidity, corrosion, heavy rain and hail, fog and high winds shall be addressed in the design. Additionally, the nature of the terrain in the perimeter of Property Protection Areas and Controlled/Critical Areas shall be given detailed consideration. Devices and equipment for interior Intrusion Detection System shall meet Federal Specification W-A-450-C, Alarm Systems, Protective, Interior, or be approved by the DOE.

13.11.1 INTRUSION DETECTION SYSTEM COMPONENTS

Electronic detection systems shall be designed to meet site specific protection needs and as a minimum meet the following criteria:

a. All detection/alarm devices shall be connected to monitor/display panels in the CAS.

b. Exterior sensors that serve as the primary means of detection at a security area perimeter shall be designed to provide assurance that a person crossing the perimeter will be detected whether walking, running, jumping, crawling, rolling, cutting, or climbing at any point in the detection zone.

c. All detection/alarm devices, including transmission lines to annunciators, shall be failure and tamper-indicating in both the access and secure modes. This may be accomplished either using separate physical inputs to the Intrusion Detection System or through the use of supervisory alarms such as “loss of communication” or “loss of video signal” in very specific and limited instances. The use of supervisory alarms in place of a separate physical tamper alarm must be approved by DOE Security.

d. Alarm lines shall be continuously supervised to detect any attempts to short, open, or substitute a bogus signal for the legitimate "no alarm" signal in a surreptitious attempt to bypass the alarm system.

e. Intrusion alarm systems shall have a primary and auxiliary power source. Switch-over to the auxiliary power source shall be automatic upon failure of the primary power source. An alarm condition shall be indicated at the monitor upon failure of all power sources.

f. Additional clear zones required for system operations will be afforded per manufacturer specifications.

g. Intrusion Detection System hardware shall be peened, or spot welded to mitigate tampering or easy removal.

13.12 INTRUSION ASSESSMENT SYSTEM

The IAS shall be provided to augment perimeter protection since its use permits less frequent visual inspection by protection force personnel. Intrusion assessment shall be accomplished by CCTV. The IAS shall have cameras and lighting of such quality, positioning, and intensity to provide timely recognition and distinction between humans or other objects responsible for activating the Intrusion Detection System.

The assessment system shall provide assurance that:

a. Alarms can be assessed reliably, accurately, and in a timely manner, so that an appropriate response can be initiated.

b. Activities of intruders can be assessed so that response can be directed.

c. False and nuisance alarms can be rapidly assessed with minimal effort so that the response is not degraded.

13.12.1 CLOSED-CIRCUIT TELEVISION REQUIREMENTS

CCTV monitors and controls shall be located in the CAS and shall be operated and monitored by protection force personnel. CCTV camera coverage shall be provided [redacted] Cameras must be in sufficient number to provide total observation of site perimeters by the ADAS Operator.

13.12.1.1 Closed Circuit Television System Components

13.12.1.1.1 **Cameras.** Fixed focus cameras shall be used [redacted]

13.12.1.1.2 **Camera Controls.** The camera master control panel for pan tilt zoom cameras shall be located at the CAS console.

13.12.1.1.3 **Monitors.** Monitors shall match the sensitivity and resolution requirements and be compatible with the cameras and the security console. Individual monitors may be provided for each camera or provided with monitor switching to permit automatic elapsed time switching with an adjustable time duration of 0.5 to 5 minutes, and both manual and automatic switching to an area of detection. When switching is provided, sufficient monitors shall be installed so that at least one monitor is in the switching mode when the remainder is manually or automatically switched each to a different camera.

13.12.1.1.4 **Video Recording.** A video recording capability shall be provided to record events viewed as a result of Intrusion Detection System switching. A video timer shall superimpose date and time information on the image being recorded.

CHAPTER 14

MONITORING AND CONTROL, INSTRUMENTATION, AND DATA ACQUISITION SYSTEMS

14.1 PURPOSE

This chapter establishes the design criteria for the Strategic Petroleum Reserve (SPR) for monitoring and control, instrumentation system, and data acquisition systems.

14.2 DESIGN REQUIREMENTS

Refer to the Control System Functional Specification, MS-I-910-006 for additional control system operational philosophy and implementation.

14.2.1 CONTROL CENTERS

1.4.2.1.1 Distributed Control System

Each storage site shall be controllable from the site's Central Control Room (CCR) via a Distributed Control System (DCS). The DCS shall enable the operators to perform all the actions required for complete monitoring and control of the SPR site. Site control systems shall be fully redundant with automatic transfer to backup system. Should both systems fail they will fail safely to manual operation.

14.2.1.2 Site Control Center

Each storage site shall be operated from an onsite control facility located in the site's CCR. All control commands for process systems shall be initiated from this control facility. A minimum of two terminals and keyboards shall be provided for operator interface. Data presented on the display shall be controlled by using either simple mnemonic keyboard entry commands and/or simple call up schemes such as touch screen LCD's, trackball, mouse, etc. Sufficient non-volatile storage shall be provided to record all sensor and control values required to reconstruct site operation during oil storage or recovery.

14.2.1.3 Management Information Center

One MIC is located in the DOE facility in New Orleans, Louisiana. A second MIC is located in the Washington, D.C., DOE Headquarters Command Center. Configuration data concerning each storage facility shall be transmitted to the MIC. Available data shall include current status of the facility operation mode and critical conditions. As a minimum, this shall include status of site complex oil inventory, facility mode selection, flow rates, oil spill, and security problems. Communications from the MIC to the site shall be through the OCC.

14.2.2 DISTRIBUTED CONTROL SYSTEM

14.2.2.1 The DCS shall provide functional control for all modes of operation. The DCS shall accept and process all data inputs for use in control algorithms, and route data to display and storage peripherals. The DCS shall not require high level language programming for the development of basic control, data acquisition, and report generation programs. The DCS shall record stored data and direct it to output peripherals (i.e., LCD displays or hard copy devices) upon command.

The DCS shall be designed so that control system failures will result in minimum overall system impact, safety being considered paramount.

The entire DCS shall be designed for continuous operation using a target availability of 0.9999. Availability is defined as MTBF/(MTBF & MTTR), where MTBF is the mean time between failures and MTTR is the mean time to repair. Availability shall be possible by employing a reliable means of fault tolerance to minimize the effect of any single failure on process control and monitoring. Redundant operator terminals, processors, and power supplies shall be provided as an integral part of the DCS. Upon detection of a failure in a primary device, the redundant device shall automatically take over the operation with appropriate alarming on the operator display.

The DCS shall comply with the following minimum performance requirements:

a. **Alarm Response**: The DCS shall annunciate the display alarms on the Operator Station display within 2 seconds.

b. **Video Display Response**: Any operator terminal display should be capable of displaying, with current dynamic data, within 2 seconds after an operator request. After a display is on the operator terminal, all dynamic data on the display should be capable of updating every 2 seconds.

c. **Command Action Response**: Commands from the operator via the Operator Stations shall be capable of resulting in an appropriate output to the control device within 1 second following the command to execute.

d. **Analog Conversion Accuracy**: Digital values of analog inputs have an accuracy of at least +/- 0.025% of full scale (12 Bits).

e. **Scan time**: 250 milliseconds (scan all inputs; execute all control algorithms, calculations, interlock functions, sequential control operations, etc.; output all control signals to final control elements).

f. The DCS shall have automatic restart after complete power failure. Controller modes (Auto/Manual) and values for all outputs shall be user configurable.

g. **Diagnostics**: Full diagnostics shall be provided such that no first order failure can go undetected. On failure, an alarm shall be generated at the Operator

Station. A system display shall also show the failed module location, module type, and unique identifier.

Equipment and processes not directly controlled shall be monitored with status and out of tolerance conditions annunciated and recorded.

All measurements for equipment safety shall be monitored for interlocking purposes (e.g., temperature, vibration, pressure). Likewise, all necessary measurements of the process shall be provided (e.g., flow, temperature, density) to insure the proper monitoring and control of all fluid flow.

Upon detection of an alarm or data indicating unsafe or self-destructive operation, the control system shall safely shutdown the equipment involved.

14.2.2.2 **Control Valves.** Control valves shall be sized for a normal flow at no more than 70 percent of the capacity of the valve. Butterfly valves shall be sized for a maximum flow at 60-degree angular opening, except for a characterized vane valve which may be sized at 90-degree angular opening.

Where valve noise exceeds Occupational Safety and Health Act (OSHA) regulations of 90 DBA 3 feet from the pipe and 3 feet downstream of the valve, noise abatement procedures shall be used.

14.2.2.3 **Control of Rotating Machinery.** Automatic shutdowns shall be furnished to protect machinery from malfunctions which could cause personnel hazard or rapid and extensive equipment damage.

Upon loss of power or shutdown, each component in the control system and the safety shutdown system must assume a condition that minimizes personnel hazard and equipment damage. All shutdown switches shall be primary control devices.

Control logic shall be provided for all alarm and control sequences.

A pre-shutdown alarm shall precede each shutdown to allow time for operator action. A separate alarm shall be provided at shutdown to identify the source of shutdown. The sequence is alarm, then alarm and shutdown. The alarm at shutdown shall be activated by the same sensor which initiates the shutdown. Upon shutdown, the machine shall remain locked out until reset.

All alarm circuits and shutdown circuits shall be normally energized, i.e., the alarm shall sound, or the shutdown shall be initiated when the circuit is de-energized.

Rotating machinery shall be shut down by interrupting the source of energy to the driver, e.g., at the starter.

If a bypass is used to override a shutdown interlock, an indicator shall be provided on the operator terminal to note this condition.

Bypass systems shall be designed, and appropriate test connections shall be provided so that a complete functional test of the shutdown system can be performed.

14.2.2.4 **Alarm Circuitry.** Alarm shall be defined as those audible and visual signals for alerting operating personnel of the need to take corrective process action or to be advised of an operating condition which is deviating from preset limits.

The DCS shall include an alarm management system for processing and displaying alarm conditions to the operator. Alarms shall be prioritized such that those which affect safety or oil loss will be reported first. Alarm reporting shall be accomplished within two seconds after a sensor detects the alarm condition.

Trouble contact-actuating alarms shall be initiated by opening contacts which are closed during normal operation.

Alarms shall operate under the same condition as the equipment they protect, such as through power failure, i.e., if equipment continues to operate through power failure, its associated alarms must also operate through power failure. Additionally, alarms shall be recorded and displayed as specified in this chapter.

14.2.3 DISTRIBUTED CONTROL SYSTEM PROCESSOR

14.2.3.1 The DCS shall have redundant processors and system power supplies. The DCS shall provide for at least two terminals for operator interface, together with supporting software and memory. The displays shall be capable of depicting tanks, pipelines, pumps, and other equipment in graphic fashion, together with alphanumeric equipment and variable designations. Symbols and solid and dashed lines shall be used in graphic displays. Real time color displays shall be selected by the operator to review the process. Displays shall be three types as follows:

a. Process displays - These shall include:

   (1) Equipment group displays showing associated groups of equipment (such as a pump and associated MOVs and instruments)

   (2) System and subsystem displays of groups of equipment (such as brine disposal area, cavern area, etc.)

   (3) Overview displays of entire facility status

   (4) Tabular displays (e.g., alarm summaries)

b. Interactive graphic displays with command-and-control capability.

c. Trend displays - These shall graphically plot real time and historical values of measurements versus time.

The following functions shall be supported:

a. Report writing

b. Alarm logging

c. Programming

d. Graphic updates

e. Data communications to other facilities

f. Historical data collection

g. Analog controller monitoring and set point control

The displays below shall have the following performance:

14.2.3.1.1 **System Status.** The system status display shall be available to indicate the location and nature of malfunctions.

14.2.3.1.2 **Control.** Every analog and digital point in the control system shall be available for display. Set-point, output, and control modes shall be capable of being manipulated through the display. The information provided by the display shall be individual deviations between variables and their set points or target value. High and low alarms shall be shown when tripped.

14.2.3.1.3 **Trend.** Historical trend of any analog point on the screen shall be available for selection and display on command. The historical trend display shall be able to represent the trend on variable time bases. At least two such displays shall be displayed on the screen at one time. While this display is on the screen, it shall be possible to manipulate each of the loops displayed from the operator terminal. The historical display shall be updated with real-time values automatically.

14.2.3.1.4 **Alarm.** The alarm display shall present an audio signal for the point in alarm. Time of occurrence, alarm type, point identification, and point description shall be displayed. The display shall allow alarm grouping of those alarms associated with a specific operating unit or site area.

14.2.3.2 Hardcopy Requirements

The control system will have a hardcopy device which can produce a color copy of any of the console operator displays, including graphics.

The DCS shall be capable of printing real time trends from the operator console, with sample point at least once every two seconds. The print process shall be fast enough not to interfere with the operator console tasks. The operator shall be capable of selecting, for printing, multiple trends without having to wait for the trend to complete printing before selecting another trend for printing. The DCS or printer may spool the print jobs before printing if necessary.

The log/alarm program will establish format and intervals for process logging and alarming. This allows loop selection, individual selection of high and low alarm points, alarm priority selections and conversion of engineering units. The program will contain a demand log routine for individual or loop logging by keyboard request.

14.2.3.3 Site Graphical Overview Monitor

Each site control room may include a site graphical overview monitor. The monitor shall provide status indicators on the panel flow lines for all critical valves and pumps and shall have status of alarms.

14.2.3.4 Video Monitors

Video monitors for graphic display or security purposes shall accept and display video baseband signals with the same characteristics as a broadcast television video baseband signal or better. Display shall not introduce any visible picture distortion or audio distortion into the reproduced television signal with input signal levels of 1000 micro-volts or greater. As a minimum, the display shall include front panel on-off and brightness controls and be adjustable for normal viewing under background lighting conditions of from 50 to100 foot-candles.

14.2.4 INSTRUMENTATION SYSTEMS

14.2.4.1 General

The instrument system design shall provide all sensors necessary to indicate, control, monitor operations, and record data to assure reliability, safety, and flexibility of operation. The instrument system shall input transducer signals representing temperature, flow, level, pressure, gas, pH, vibration, speed, density, and conductance to the distributed control system. Instrumentation shall, when appropriate, include all local display and readout devices.

Construction materials for instruments or instrument parts in contact with process fluid shall conform to National Association of Corrosion Engineers (NACE) and the environmental factors addressed in Chapter 10 and those used in the fabrication of the process line or equipment, except in those cases where the design features of an instrument limits the use of other construction materials.

Pressure and temperature ratings of instruments, or components which are an integral part of a closed system, e.g., control valves or float cages, shall conform to the ratings of that system.

Electrical construction of instruments shall be determined by the location or occupancy as defined by the National Electric Code (NEC) covering hazardous locations. Intrinsically safe instruments and connections shall conform to American National Standards Institute (ANSI)/Instrument Society of American (ISA) RP 12.06.01.

Scales and ranges for instruments shall be selected to meet the application. As a general rule, the scale or display range should be chosen so that the expected value of the measured variable will fall between 60 and 80 percent of full scale. Accuracy and repeatability shall conform to the specific requirement.

An identification tag shall be attached to each piece of instrumentation equipment. The tags shall be of sturdy, weather-resistant material, permanently fastened to the equipment.

Instruments, control devices, and components shall be designed and tested over the temperature and humidity ranges anticipated at their permanent locations. Electrical signal levels shall be maintained greater than or equal to 9 dB above electrical noise level, or appropriate shielding or spacing action shall be incorporated.

Enclosures for field-mounted electrical instruments shall be rated in accordance with the electrical classification assigned to the area in which they will be installed and shall be suitable for outdoor installation if required and compatible with the environment.

Instrument panels and enclosures shall be mounted so that they are self-supporting and free of vibration problems. Mounting surfaces shall be smooth and blemish free. Front and rear spacing shall allow free access for maintenance functions.

Electronic wiring design and/or fiber optics design and implementation techniques shall maximize reliability, ensure personnel safety, and minimize electrical interference. All instrument cabling or fiber optics shall be designed and installed for a minimum 20-year life and shall include 25 percent spare line capacity.

The manufacturer's recommendations shall be followed when wiring special equipment, such as turbine meters, density meters, etc.

Each pair of wires or fiber optics shall be identified at all junctions where other wires are present. All terminals shall be clearly identified. Terminals on the back of the main control panel shall be labeled with the instrument loop number.

Loading of signal sources shall be within the manufacturer's published limits. Voltage signal receivers shall have an input impedance of at least 100 times the impedance in the rest of the circuit. This includes the wiring and the output of the signal source.

Signal wiring shall be separated from power wiring and electrical equipment to minimize noise. The following are minimum required separation distances between the signal wiring and the power conductors for parallel runs. Crossovers shall be made at right angles.

MINIMUM SPACING FOR SIGNAL WIRING

POWER WIRING VOLTAGE	CURRENT CAPACITY (AMPS)	SEPARATION (IN.)
110	10	6
220	50	10
440	200	12
5000	800	20

Where a strong magnetic field is known to exist, signal wiring shall be routed with respect to this field to minimize interference parallel to the magnetic flux lines. Signal wiring shall not normally be routed through areas where ambient temperatures exceed 176°F (80°C).

Where wiring is used instead of fiber optics from a field junction box to individual field instruments the wiring shall consist of twisted pairs run in conduit. The conduit installation shall meet the hazardous location requirements and methods as defined in Chapter 5 - “Electrical.” No joints or splices shall be permitted in signal conductors, except aboveground at terminal junction boxes.

Transmission lines for instruments and transducers should be grouped together, and run in multi-conductor cable. Multi-conductor cable shall be at least 18 gauge and have an overall shield. Individual twisted pairs shall be shielded to minimize cross-coupling between signal lines. All wire pairs shall be twisted with at least eight twists per foot. Multi-conductor cables shall have color coded wires. Cables which are direct buried underground shall be gel filled to inhibit wicking. Fiber optics shall be identified by color or number.

All signal returns shall be grounded at one end only. Continuity of the return shall be maintained throughout the cable run and isolated from ground at instruments, junction boxes, etc. Shields shall be terminated at one end only. All connections from the control room-based controller to a field unit shall be designed so that an open or short circuit will minimize upset of the local control loop.

Cable and fiber optics runs shall be kept as short as possible, allowing extra length for connecting to the terminal board. The installed cable end radius shall be not less than the minimum bend radius recommended by the manufacturer or NEC, whichever is larger. Sleeves or grommets shall be used to protect cables from vibration at points where they pass around sharp corners, through walls, panel cabinets, etc.

14.2.4.1.1 **Transient Protection.** Equipment and cables shall be protected from surges on power and signal lines caused by voltage surges and lightning, i.e., size protection with the largest Joule rating and lowest clamping level available for the application. Provide protection of equipment near the power panel to ensure protection against surges. All cables and conductors shall have lightning arrestor networks installed at each end. Provide both primary detection devices and secondary protectors as a minimum which shall reduce dangerous voltages to non-damage levels. Fuses shall not be permitted as protection devices. Suitable forms are Zener diodes, optical isolators, varistors, and combinations of these with the proper interconnection circuitry to insure their effectiveness. Transient protection shall protect against spikes up to 1,000 volts peak voltage with a 1 microsecond rise time and 100 microsecond decay time. The protective device shall be automatic and self-restoring and shall be on duty at all times. All failure modes of each surge protection shall be fail-open or to ground. Use of gas discharge tubes alone is unacceptable. Hybrid (stage) surge protective devices are acceptable. All designs shall meet National Fire Protection Association (NFPA) 75.

14.2.4.2 Indicators/Transmitters

14.2.4.2.1 Level indicators/transmitters at each of the storage tanks shall be appropriate technology for the fluid being measured. Instruments for custody transfer tanks shall have accuracy to within ± 1/8-inch and readout shall be accurate to 1/16-inch. Process level indicator transmitters and switches shall be appropriate technology for the fluid being measured.

14.2.4.2.2 Pressure indicators/transmitters shall be suitable for 100 percent over range and shall operate accurately without the need for re-calibration or adjustment due to this range of overpressure. Transmitters shall have 4-20 milliamps direct current output. Pressure elements shall be steel when used in crude oil service, stainless steel in brine or raw water service, and bronze or steel for use in utilities, i.e., potable, or fresh water, or air.

Pressure gauges shall be 1/2-inch diameter thread, bottom connected, 4-1/2-inch diameter dial with bourdon tube elements. Bourdon tube pressure gauges connected to water with significant quantities of suspended solids or salt content shall be of the oil diaphragm type and connected to the system to be monitored with 1-inch minimum diameter piping. Pointers shall have micrometer adjustment. Cases shall normally be phenolic with a snap-type case ring. Pressure elements shall be 4130 alloy steel with forged alloy. Rotary geared movement shall be stainless steel or a combination of stainless steel and hardened model.

14.2.4.2.3 Temperature indicators/transmitters shall be measured by resistance temperature device (RTDs), 100 ohms platinum at 32°F.

Storage tank temperature shall be determined by the RTD method. The temperature shall be displayed at the central console to the nearest degree with total system accuracy of ± 1°F. The temperature sensor shall not be any closer than four feet from the tank bottom unless tank design prohibits such.

Temperature test wells shall be machined from 304 stainless steel bar stock and furnished with permanently attached brass plug and chain. Bore shall be 7/16-inch to allow inserting a glass stem mercury test thermometer.

Densitometers, analyzers, samplers, etc. supplied with an integral RTD shall use the temperature from the integral RTD for input in calculations.

14.2.4.2.4 Flow indicators/transmitters for major flow measurement shall be comprised of a flow measurement system wherein all data measurement such as flow, pressure, temperature, and density shall be inputs to the equation which continually solves for gross standard volume to correct for any measurement error caused by change in rate of flow or fluid characteristics API, Manual of Petroleum Measurement Standards (MPMS), Chapter 5 and 12.

The primary major flow measurement devices shall meet the requirements of Chapter 9.

The criteria for measuring oil flow for custody transfer will be based on Chapter 9.

The primary flow measurement element for other than custody transfer shall measure total raw water to the site and total brine from the site as well as raw water and crude oil at each cavern. Flow measuring devices meeting the requirements of Chapter 9 shall be used to measure oil flow at each cavern. These measurements shall provide continuous remote monitoring at the control room.

14.2.4.3 Analyzers/Controllers

The design shall provide analyzers/controllers to ensure that OSHA, state, and local environmental standards will be met. Emissions of oil, brine, and gases shall be monitored, analyzed, controlled, and alarmed when out of limits. Analyzers/controllers shall be provided for, but limited to, combustible gas, CO_2, O_2, CO, H_2S, pH, and conductivity.

14.2.5 SYSTEM DESIGN

The monitoring and control, instrumentation, and data acquisition system shall do the following:

14.2.5.1 Include in the control loop specifications a requirement for the examination of the dynamic elements in the control loop and the mathematical analysis of dead time together with 1/4 amplitude damping. Control valve characteristics shall be a part of this criteria.

14.2.5.2 Prove the characteristics of real processes and, by analysis of common loops, establish for each loop the requirements for linear or non-linear control mechanisms and/or control valve gain.

14.2.5.3 Determine if there is any advantage in employing multiple loops such as ratio, feed forward or cascade systems and the requirement, if any, for adaptive control systems, and shall use such techniques if other than minimal advantages can be obtained.

14.2.5.4 Use control system terminology as shown in ISA Standard 51.1, Process Instrumentation Terminology, where applicable, for developing drawings and manuals. Where ISA Standard 51.1 is not applicable, use DOE/contractor devised control system terminology.

14.2.5.5 Use symbols and identification as set forth in ISA Standards 5.1.

14.2.5.6 Require each instrument loop diagram to conform in all details to ISA Standard 5.4.

14.3 SPECIFIC REQUIREMENTS

14.3.1 SYSTEM DESIGN

14.3.1.1 Instrumentation-Solution Mines

Instrumentation shall determine cavern inventory by accurately metering to 1.0 percent of total volume of oil flow into and out of the cavern. Brine and raw water shall be metered to 5.0 percent of total volume. Instrumentation and control for leaching shall be provided to prevent over pressurization of the casing shoe and related facility and to insure personnel and equipment safety. Detection of any oil entering the brine pond or tanks shall be required.

14.3.1.2 Instrumentation - Storage Tanks

Remote readouts shall be provided where required for site operation. As a minimum, the following shall be provided: (Also refer to Chapter 6)

14.3.1.2.1 One level indicator device with local readout to supplement remote readout instrumentation.

14.3.1.2.2 One pressure gauge connected to the vapor space of the vessel. A block valve shall be installed between the gauge and the vessel, and provision made for venting the gauge for maintenance.

14.3.1.2.3 One temperature indicator and/or temperature element for measuring the temperature of the liquid contents of the vessel locally. Local and/or remote readout shall be provided in accordance with operating requirements.

14.3.1.2.4 The following additional instruments should also be provided where required:

a. A high-level alarm to guard against overfilling of the vessel. The alarm shall activate as the level approaches the maximum filling level. The maximum quantity to be filled into a vessel shall comply with local regulations, or in the absence of such, with the requirements of the Institute of Petroleum Refining (IP) LPG Safety Code. The maximum fill level of the tank should be such that the tank will not become liquid full after expansion of the contents from the highest rise of temperature which the contents will reach in service. This limit shall apply regardless of the ambient temperature and product temperature at the time of filling.

   A high-high level alarm shall also be provided on a separate transmitter to ensure a redundant safeguard is available.

b. A low-level alarm to operate at a level which shall give adequate time for operator action to prevent the vessel being completely emptied during discharge operations to avoid pumping difficulties.

   In the case of floating roof tanks, consideration shall be given to providing an additional low-level alarm to indicate the roof is approaching the level at which the roof will be set on its support legs. In addition, an alarm should be provided if the tank is provided with mixers that must be deactivated when the tank roof approaches a certain level.

14.3.1.2.5 Sample points shall be provided to enable representative samples to be taken from one or more levels depending on the size of the vessel. Double valving shall be employed at these points.

14.3.1.2.6 Two grounding connections shall be provided.

14.3.1.2.7 A remotely controlled emergency shut-off valve shall be installed at or near the vessel outlet and inlet nozzles.

14.4 PROCESS CONTROL SYSTEMS CONFIGURATION MANAGEMENT

The Management and Operations (M&O) contractor has the responsibility and authority for comprehensive Configuration Management (CM) from design through operations and maintenance of site process control system design and construct packages regardless of who is awarded the contract to design and construct. Also, the M&O contractor will provide input to the site process control system task specifications to assure CM requirements are included.

CHAPTER 15

COMMUNICATIONS SYSTEMS

15.1 PURPOSE

This chapter establishes the design criteria for the Strategic Petroleum Reserve (SPR) communication systems. The design of the communication systems shall provide for reliable services and equipment for voice and non-voice communications applications during construction and operation of the site. Design requirements shall provide for communications capabilities intra-site, inter-site, and off-site. The design shall incorporate GSA communications contract vehicles, Public Switched Telephone Network (PSTN), other commercial telephone networks, and spectrum dependent services (radio, microwave, etc.) to fulfill the communications requirements.

15.2 DESIGN REQUIREMENTS

15.2.1 ARCHITECTURAL – STRUCTURAL

The network control center shall be designed to facilitate expansion, and for most efficient operation and maintenance, adequate space shall be provided for test equipment, maintenance records, parts storage, tools, and work areas. Centers shall be readily accessible; adequately lighted, ventilated, and drained; and arranged to permit installation of copper and fiber cables that can support services from multiple service providers or equipment manufactures.

15.2.2 INTRA-SITE

Intra-site includes all communication within a complex or site.

15.2.3 INTER-SITE

Inter-site includes all communication between sites and/or complexes.

15.2.4 OFF-SITE

Off-site includes all communications between sites/complexes and non-SPR entities.

15.2.5 EMERGENCY POWER

In accordance with Level I and Level II criteria, the communications systems and radio system shall be capable of automatically accessing and utilizing emergency electrical power in the event of primary power failure in accordance with Chapter 5.

15.2.6 UNINTERRUPTIBLE POWER SUPPLY

In accordance with Level I and Level II criteria, the communication system and radio system shall be capable of operating on uninterruptible power supply (UPS) during an interruption or failure of primary power in accordance with Chapter 5

15.2.7 LIGHTNING AND SURGE PROTECTION

The designer shall incorporate lightning and surge protection circuitry in communications and radio systems designs in accordance with Chapter 5.

15.2.8 RELIABILITY

All communication systems and equipment shall be designed, constructed, operated, and maintained to achieve a high reliability of operation during their life. All communications equipment shall be protected against and/or specified for corrosive environment. The designer shall consider new technology, changing needs, maintenance, and repairs in modification of current equipment.

15.2.9 INTERFACE REQUIREMENTS

All SPR sites shall be linked with the Program Office Command and Control Center and the PMO Operations Control Center (OCC) for transmission of voice, data and video communications.

15.2.10 SECURITY

The communications designer shall provide capabilities required by Chapter 13.

15.2.11 EMERGENCY COMMUNICATIONS

The communications designer shall provide telecommunications equipment and services necessary for responding to emergencies. Radio communications with city, county, state, and Federal agencies shall be provided.

15.2.12 SEAWAY, TEXOMA, CAPLINE FUNCTIONAL GROUPS

The communication designer shall provide communications interfaces between sites and terminals within each functional group.

15.2.13 CONSTRUCTION PHASE

Construction phase communications are considered temporary as the site develops and shall be separate from permanent systems. All communication services and equipment shall be designed to meet the minimum requirements of the on-site personnel. Certification of radio frequency approval shall be provided prior to construction, modification, enhancement, expansion, lease or procurement of any spectrum dependent systems. Communications cabling (including fiber optics) shall be designed and routed to the same requirements as specified in Chapters 5 and 14.

On-site communications antennas shall be constructed and operational early in the construction phase.

The designer shall specify that construction contractors shall be responsible for the establishment of adequate communications systems to meet their needs without interfering with existing SPR communications. The contractor’s proposal shall, however, be presented to the Contracting Officer for review and approval.

15.2.14 OPERATIONS PHASE

Toward the end of the construction phase, the site shall be provided with permanent communication services and equipment compatible with SPR operational needs. Temporary construction-related communications shall be removed, and permanent devices installed and tested.

15.2.15 TERMINAL SUPPORT SYSTEMS

Redundant communication systems shall be available for sites to communicate to oil terminals.

15.2.16 PUBLIC ADDRESS SYSTEM

Each site shall be equipped with a public address system for use in emergencies. These systems should be capable of selective zone and all-zone announcing.

15.2.17 ACCEPTANCE TESTING

Acceptance testing shall be performed to verify that all communication systems conform to the design specifications, test specifications, and criteria.

15.2.18 RADIO SYSTEMS

The communications designer shall provide radio systems for normal and redundant emergency communications to/from all DOE or terminal/pipeline access locations. The site control center and the local public safety agency shall be able to monitor each other from DOE-provided equipment.

Each facility shall have the capability to communicate to all limits of the immediate project.

On-site, multi-frequency capability shall isolate construction, safety, and security activities. All channels shall be monitored simultaneously.

The installed location of the transmitter/receiver shall be in an area that will insure operational effectiveness. Pipeline communications shall meet 49 Code of Federal Regulations (CFR) 195.

Fire, safety, and security vehicles shall be equipped with mobile units. Vehicles of site supervisory personnel shall be equipped for emergency response. Safety and Security shall have direct communications with local support agencies.

Portable units shall be capable of portable to portable, portable to base, and portable to repeater stations, as required.

15.3 SPECIFIC REQUIREMENTS

The telephone communications shall provide independent means of communicating from each site to the SPR Communications Center and emergency response organizations.

15.3.1 SYSTEMS DESIGN/RADIOS

Communication systems shall be designed to state of the art modular construction and shall be expandable to allow necessary growth.

Radio equipment shall be of all solid-state design. All radio equipment shall meet or exceed SPR specifications.

15.3.2 SYSTEM DESIGN TELECOMMUNICATIONS SYSTEMS

15.3.2.1 **General**. The system shall be comprised of the following items:

a. Telephone instruments and auxiliary equipment, which enables users to place and receive calls.

b. A computerized system that automatically switches station lines and trunk circuits.

c. Voice paging system.

d. If the system requires protective connecting arrangements at the interfaces with other interconnected systems that the local tariffed telephone company provides, they shall be provided by the Contractor as components of the system.

15.3.2.2 **Interconnected Systems**. The system shall have the capability to be connected by analog, digital or IP based capabilities to facsimile terminals, workstations, and data communications equipment.

It shall be interconnected by the specified number of trunk circuits with the local central office, foreign exchange central offices and the FTS switching network.

15.3.2.3 **System Interfaces**. The system shall provide trunk circuitry that is capable of operating with analog or digital trunks.

15.3.3 STATION LINE AND TRUNK CAPACITIES

The system shall be equipped and programmed with expanded capacity to accommodate expanding technological capabilities.

15.3.4 AUTO ATTENDANT CAPABILITIES

The system shall be equipped to automatically route external calls to individuals, organizations, and functional departments. The system should route calls without human assistance and have expandable capacity.

15.3.5 DIALING

The system design shall provide for communication industry standard functional dialing parameters.

15.3.6 SYSTEM SOFTWARE

Software for each system shall be field proven.

a. Each system shall provide the ability to enter changes locally and/or remotely.

b. Each system shall provide redundant central processors operating in a tandem (hot standby) mode.

15.4 DATA REQUIREMENTS/FEATURES

At a minimum, the system shall support routing of voice, data, and video traffic.

15.5 ADMINISTRATIVE DATA RECORDING

The system shall provide for traffic usage, systems performance, and station message recording.

15.6 SYSTEM EQUIPMENT ROOM

Each system shall operate properly with the ambient temperature between 40°F and 100°F and with the ambient relative humidity between 20 percent and 85 percent.

15.7 SYSTEM OPERATING POWER

Each system shall operate on power provided by DOE through lightning and surge protection from the local power utility company, or a back-up source.

Each system shall have the ability to operate properly from UPS and emergency generator.

Grounding will meet the requirements of Chapters 5 and 14.

15.8 SYSTEM CABLING/WIRING/FIBER OPTICS

All communications cabling or fiber optics shall be designed and installed for a minimum 20-year life and shall include 50 percent spare line capability. Each cable shall be identified at all junctions where other cables are present. All terminals shall be clearly identified.

15.8.1 OUTSIDE CABLE/FIBER OPTICS

Outside cabling/fiber optics shall meet the codes and standards stated herein. The cabling will be provided up to the cross connect field for termination, identification, and testing by the contractor prior to cutover of the system. Contractor shall provide fiber optics or cabling from the switching equipment to the cross connect field.

15.8.2 STATION WIRING

Station wiring shall be provided by DOE/SPRPMO. All station equipment shall be provided by DOE/SPRPMO. All station equipment shall be expandable for operations and data processing of communications. The station wiring will be provided up to the cross connect field for termination, identification, and testing by the Contractor prior to cutover of the system. Contractor shall provide cabling/fiber optics from the switching equipment to the cross connect field.

15.9 SYSTEM STANDARDS

Each system provided shall be in compliance with all International Telecommunications Union (ITU), and Federal Communications Commission (FCC) rules and regulations, and corresponding regulations of the National Telecommunications and Information Administration (NTIA) regarding electromagnetic interference (EMI). In particular, attention will be focused on Part 15 of the FCC Rules and Chapter 5 of the NTIA Manual.

15.10 SYSTEM COMPATIBILITY

Each system provided shall be fully compatible with and capable of extending to all system users the ability to access and utilize the capabilities of the following:

a. FTS ISDN PRI Trunking

b. MPLS-Wide Area Networking

(1) SIP Trunking

(2) Analog CO trunks

(3) Other Common Carriers (OCC)

CHAPTER 16

SYSTEMS EFFECTIVENESS

16.1 PURPOSE

This chapter provides requirements for systems effectiveness activities that will be conducted to support the development, evaluation, selection of equipment, personnel considerations, and procedures required to achieve total life cycle performance within cost and schedule limitations.

The purpose of systems effectiveness is to achieve those processes of management, analysis, product assurance, and integrated logistics support required to optimize the development of performance of a facility to meet specified objectives.

16.2 REQUIREMENTS - RELIABILITY

The objective of the reliability program is to implement reliability requirements that assure the integrity of the SPR system is preserved.

Design, fabrication, and installation of all material and equipment specified shall have a probability of functioning 95 percent or better of operational time during the intended 20-year life span of the complex under the site's environmental conditions, Chapter 10, and the remainder of this criterion.

16.2.1 RELIABILITY/AVAILABILITY GOALS

Reliability/Availability goals specified in Level II criteria shall be translated into quantitative requirements in design for critical systems and equipment. The facility designer shall identify and classify all systems and subsystems as "Critical" or "Non-critical." Criticality shall be determined based on those facility items for which failure would affect safety to equipment, personnel, and environment, and would create excessive maintenance problems, and where failure will prevent mission accomplishment (movement of oil).

16.2.2 SYSTEM RELIABILITY ANALYSIS

This concept of reliability analysis within the framework of this document shall include system logic diagrams, reliability engineering apportionment, reliability engineering prediction, and failure mode effect analysis. The results of these analyses shall be incorporated into the design plans and specifications for construction.

16.2.2.1 System Logic Diagrams

The system logic (block) diagram is a reliability function used to show series independency and functional dependency of the various components in a system or subsystem. Their sole purpose is to list in series the components that must operate for proper system operation. Included in the diagram are the components required for check-out of the system such as pressure gages, etc. Redundant items shall be shown in parallel to portray that failure of one will not degrade the system or affect the operation. Components that are passive or have "no affect" will not be shown in block form; however, they will be listed in the lower right-hand corner of the sheet by code number.

Mechanical and electrical equipment may be shown in the same system. Electrical subsystems will follow the mechanical subsystem they support. On both the logic diagrams and the Failure Mode Effect Analysis (FMEA), electrical components in a mechanical subsystem will be listed after the mechanical components in the same subsystem.

16.2.2.2 Reliability Apportionment

Reliability apportionment shall be accomplished by allocating the goals in the Level II criteria. Apportionment shall be accomplished at the system and subsystem level. Empirical data are contained in MIL-HDBK-217F and FARADA. It is not intended that these documents be used as the sole source of information, rather they are to be used for reference and as an aid in establishing background data to perform the above task.

16.2.2.3 Reliability Prediction

The designer shall perform reliability prediction functions. This is an analytical prediction of numerical reliability. The prediction modeling activity will be developed in the early design phase. Factors resulting from this effort shall be used to guide trade-off activities pertaining to design functions, to implement the maintenance plans, to expose potential problem areas that require solutions, and to identify additional testing needs and other analyses and studies as required. MIL-HDBK-217F sets forth an analytical approach for performing reliability predictions and general criteria required, and list the steps in making the prediction, failure rates, and necessary formulas to complete the task. This reference is not intended to be used as a sole-source of information but as a guide and an aid in acquiring usable criteria. Sources for failure rates shall be documented. Manufacturers recommend Mean Time Between Failures (MTBF) and Mean Time to Repair (MTTR) should be obtained for all major items and major components of those items.

16.2.2.4 Failure Mode and Effect Analysis

FMEA shall be used to define and document the various subsystems/assemblies and components of a system. Further, the FMEA will be used to determine the effects on the system due to failure of any individual component/assembly/module/etc., in any of their possible modes. This type analysis shall be used to expose potentially troublesome or dangerous conditions that may exist in the system. Effective use of the FMEA can result in component test requirements, the need for redesign of critical subsystems, and special maintenance or redundancy capability. FMEA shall be performed on all systems descending to the component level. The analysis will be based on single component failure and shall consist of concise statements regarding failure modes and the effects of these failures.

16.3 INTEGRATED LOGISTICS SUPPORT

SPR Integrated Logistics Support (ILS) requirements may be found in Department of Energy (DOE)/SPR Order 430.1C. ILS is a management concept which has been developed to optimize systems effectiveness and life cycle costs within performance and readiness requirements. The purpose of ILS is to develop systems that are cost-effective, reliable, and that are maintained, operated, and supported when in the operational mode.

The designer shall prepare a site-specific ILS plan for newly designed sites and changes for major modifications to existing sites for inclusion in the SPR Integrated Logistics Support Master Plan (ILSMP). The plan shall establish procedures and responsibilities for all system support activities.

To ensure maintainability, a planned maintenance and support environment shall be incorporated into equipment design. System components shall be easily and safely accessible by maintenance personnel under existing site environmental conditions.

16.3.1 MAINTENANCE

The plan shall provide:

- Information on the inventory control point for spares, repair parts and the repair of repairables.
- Data relating to requirements for training, technical publications and support equipment.
- Direction for maintenance of the equipment (who has responsibility at each level of maintenance).
- The basis for logistic requirements determinations (failure rates, maintenance skill requirements, special tools required).
- A means for monitoring how well the equipment is being maintained.

- A Level of Repair Analysis (LORA) shall be performed to identify the preferred level at which each maintenance action shall be performed.

16.3.2 SUPPLY SUPPORT

A supply support system shall be defined that will identify the selection, procurement, storage, and handling of spares and repair parts. The system will also address the establishment of inventory levels and reordering to maintain established inventory levels.

Additionally, the system will identify how the repair of repairables will be managed.

16.3.3 SPARE PARTS

The construction contractor shall provide a list of recommended spares and initial quantities to the Management and Operating (M&O) contractor during construction. The construction contractor shall also provide parts listings of all parts in supplied equipment to the M&O contractor for inclusion in the Technical Data Center. The M&O contractor shall then use these lists in the spares/repair parts analysis. The M&O contractor will identify bills of material based on the provided parts lists and the LORA. The bills of material will be laid out by site, by system, by major component, and each part of the component.

16.3.4 SUPPORT AND TEST EQUIPMENT

The construction contractor shall identify special support and test equipment required by the M&O contractor based on the LORA. Additionally, the construction contractor shall arrange to acquire these items.

16.3.5 TECHNICAL DATA

The designer shall determine the technical data requirements based on the analysis of operator needs and maintenance actions anticipated. Technical data shall be acquired as an integral part of equipment procurement. The procedures and contract language will ensure these data are acquired.

16.3.6 MAINTENANCE AND WAREHOUSING FACILITIES

The designer shall determine the SPR's ILS related facilities requirements based on the anticipated maintenance requirements, the expected spares and repair parts consumption rates, and the location of these maintenance actions. An economic analysis shall be used to determine the size and location of these storage and repair facilities. The designer shall ensure that permanent onsite warehousing is completed early so that initial and construction spares can be permanently warehoused, cared for and turned over to the M&O contractor in an organized manner.

16.3.7 PERSONNEL AND TRAINING

The designer and procuring organization shall provide a training program plan identifying the activities and effort that must be addressed and accomplished to provide:

- An organized definition of the total skill and manpower requirements for the system designed.
- A complete schedule for the development and maintenance of critical skills for the life cycle of the system designed.
- A schedule for the development and accomplishment of all training courses required for all operating phases. General requirements for a training program are as follows:

16.3.7.1 Task and Skill Analysis

The M&O contractor shall conduct a task and skill analysis concurrent with the design effort to establish the quantitative and qualitative personnel requirements for operation and maintenance of the facility or system being designed.

16.3.7.2 Job Description

The M&O contractor shall develop job requirements and skills for various personnel positions identified as a result of the task and skill analyses and for positions outside the normal labor skills required to operate/maintain the equipment within the Task Package.

16.3.7.3 Training Requirements

After the quantitative and qualitative personnel requirements are established and the positions are identified, the actual training courses will be defined by the M&O contractor. Critical skills that are unavailable will require development of basic training courses to ensure that adequate numbers of qualified personnel are available when required for the initial operating phase.

CHAPTER 17

TESTING AND CERTIFICATION

17.1 PURPOSE

The overall objective of inspection, testing, verification, certification, and acceptance is to ensure that all equipment, storage facilities, systems, and support facilities are tested in adequate depth to ensure that Strategic Petroleum Reserve (SPR) program objectives are met. Site acceptance shall be determined through consolidated factory, subsystems, systems, and integrated systems tests that verify or certify that all design and operational requirements have been met. Certification criteria outlined in this chapter shall determine the suitability of solution-mined caverns with regard to stability, tightness, and structural integrity.

The testing and certification contractor shall be sufficiently experienced and knowledgeable to modify criteria parameters as appropriate to the conditions and characteristics dictated by a particular storage site. Testing and certification shall be discussed in terms of cavern and well tests for solution-mined caverns.

Factory test requirements shall be included in equipment specifications and shall be conducted to ensure that equipment is in accordance with design and performance requirements. Construction tests shall be basic materials and welds, mechanical, electrical, and hydrostatic tests performed to ensure proper installation and construction. Operational tests will include startup and performance tests. All testing shall be in accordance with procedures developed specifically for the item/system under test.

17.2 REQUIREMENTS - TESTING

17.2.1 CONTRACTOR RESPONSIBILITIES

In addition to the specific inspection and testing requirements called out in previous chapters and the referenced specifications, codes, and standards, the design contractor shall, during the design phase, develop the detailed inspection and testing requirements for design verification and performance testing of the components, subassemblies, assemblies, sub-system, and system which comprise the SPR elements under his cognizance. Those requirements shall address all inspection and testing during construction which demonstrate that the equipment has been fabricated and installed in conformance with the design requirements, applicable codes and standards, and the vendor data. In addition, the design contractor shall develop the inspection and test requirements for the initial checkout and start-up of the overall system and the subsystems that comprise the overall system. The design contractor shall develop the inspection and test requirements for acceptance testing the complete system to demonstrate compliance with the system performance requirements. Where conflict in test or inspection requirements occur, the most stringent shall apply.

As part of the Title III services, the design contractor shall provide inspection services during the construction phase to assure that the construction contractor's test procedures and data records meet or exceed the inspection and test requirements. The design contractor shall be responsible for organizing and presenting the applicable inspection and test results to the SPRPMO with a recommendation to accept or reject the test results. The design contractor shall issue the final test report.

The construction contractor shall be responsible for preparing the detailed inspection and test procedures necessary to demonstrate compliance with the design contractor's test requirements. Those procedures shall include step-by-step instructions to inspectors and the operators for the setup, conduct and tear down of the test operation. They shall also include data logs and/or automatic data recording requirements. Operational instrumentation and test-peculiar instrumentation shall be identified along with the necessary calibration records.

The procedures shall also include the requirements for data reduction and evaluation where applicable. The construction contractor shall be responsible for the conduct of the tests with support from the Management and Operating (M&O) contractor during start-up and acceptance testing.

The M&O contractor shall provide a cadre of personnel to assist the design contractor by reviewing the test requirements for operations and maintenance implications. The start-up test team and associated responsibilities shall be in accordance with Department of Energy (DOE) SPRPMO Order 4310.1A. The M&O will also monitor the construction testing as it may impact his operations and maintenance functions. As the construction phase nears completion, the M&O contractor shall expand the initial cadre of personnel and initiate on-site training of operations and maintenance personnel. The M&O personnel shall participate in the start-up and acceptance testing as negotiated with the construction contractor.

17.2.2 PERFORMANCE TEST PREREQUISITES

The contractor shall, through testing, demonstrate that the complex will meet or exceed the actual stated performance as specified in Level II, Performance Criteria and/or the task specifications. The following requirements apply:

- Test instruments shall bear current calibration certification prior to commencement of testing. Any instrument where operation or calibration is questionable shall be removed from the test and recalibrated. Calibration shall conform to ISO10012-1.
- All leaks detected in the piping system during hydrostatic tests shall be repaired as required by appropriate standards or codes.
- Any controls, safety valves, or instrumentation not designed to withstand the hydrostatic pressures shall be removed from the system and replaced at the completion of the tests.
- Insulated piping systems shall be hydrostatically tested prior to being insulated.
- All relief valves shall be shop tested and certified by the supplier.
- Heat tracing insulation and winterizing shall be completed to the extent necessary to permit start-up, calibration and testing, normal operation of the facility.
- Test procedures and data sheets shall be submitted for approval by the SPRPMO.
- No tests or test deviations shall be started without prior approval of the procedures and data sheets by the SPRPMO.

- The contractor shall notify the SPRPMO two weeks prior to conducting tests.

- Test data obtained from all tests shall be logged by the contractor on approved data sheets.

- All temporary facilities used for construction shall be removed and site cleanup accomplished to the extent required to permit testing and normal operation of the complex without interference, interruption, or delays unless it is determined by the contractor, with the SPRPMO approvals that the temporary construction may remain for future use.

- Painting shall be completed except for touch-up and refinishing.

- After complete installation all pressure equipment shall be field tested in the location indicated on the construction drawings and in accordance with applicable codes and standards.

- In the execution of the testing, the contractor shall take all necessary steps prior to commencement to ensure public safety and the safety of all personnel and equipment involved. Tests shall be conducted in compliance with the DOE approved Contractors' Accident Prevention program.

- The contractor shall place in operation all fire protection and safety facilities, and initiate all operating safety provisions, including practices, procedures, permits and other precautionary measures needed to ensure the safety of personnel and property, prior to performing any tests or activating any equipment.

- The instrumentation and control subsystems shall be installed, checked out and validated by means of subsystem tests prior to the start of system performance tests.

17.2.3 CONSTRUCTION TESTS

17.2.3.1 **General.** The construction contractor shall:

- Provide all materials and labor to flush, grease, lubricate, and pack all pumps, valves, and other machinery.
- Place and maintain all equipment in a state of readiness for operation in accordance with the manufacturers' instructions and recommendations.
- Remove all preservative or protective materials applied to machined surfaces including but not limited to, shafts, seals, slides, pistons, and cylinders and properly prepare equipment for normal operation.
- Flush all on-site piping and manifolds prior to the start of any subsystem or system flow tests.
- Checkout and start-up all subsystems and systems in accordance with checkout and start-up requirements developed by the design contractor.
- Pig all off-site crude oil pipelines from launcher/receiver to launcher/receiver prior to hydrostatic testing to remove debris.

17.2.3.2 **Off-site Pipeline/Piping Tests**

Off-site pipelines shall be pigged and hydrostatically tested before commissioning. The hydrostatic test pressure and time shall be not less than that required to comply with the relevant requirements of American National Standards Institute (ANSI) B31.4 and/or CFR Title 49, Section 195. The maximum test pressure at the lowest elevation point in any section of the pipeline should not exceed the pressure equivalent of 90 percent of the minimum specified yield strength of the pipe steel.

The test equipment, medium, procedures, and records shall be in accordance with American Petroleum Institute (API)-RP 1110. Failures in the line shall be located and repaired, and the line retested.

17.2.3.3 <u>On-site Piping Tests</u>

On-site piping shall be hydrostatically tested to at least the minimum requirements to which the system was designed and constructed. Failures in the line shall be located and repaired and the hydrostatic test performed again.

Firewater distribution systems shall be tested in accordance with the recommendations and requirements of National Fire Protection Association (NFPA)-24 except that no leakage shall be allowed for welded joints.

Plumbing systems shall be tested in accordance with national and local plumbing codes.

17.2.3.4 <u>Hot Tap Testing</u>

Hot-tap branch connections shall be hydrostatically tested (after welding and before cut is made on the run pipe) in accordance with API-2201 to at least the minimum requirements defined in the piping code to which the system was designed.

Installation of fillet welded full encirclement sleeves and/or fillet welded hot-tap fittings in accordance with API RP 1107 shall comply with the following requirements:

- Inspect the pipe longitudinal weld seam with florescent wet magnetic particle examination per American Society of Mechanical Engineers (ASME) Section V Article.

- Ensure the sleeve or fitting and pipe are preheated and maintained at a minimum 200 degrees F until all welding is completed.

- Use low hydrogen electrodes to reduce the likelihood of crack formation.
- Inspect the completed welds using fluorescent wet magnetic particle examination per ASME Section V, Article 7.
- Remove or repair any crack containing weld.

The designer shall consider the differential pressure that may occur between the test pressure in the branch connection and the internal pressure in the run piping to prevent collapse of the pipe. This becomes an increasingly important factor as the branch connection size approaches the run size. When full encirclement sleeve reinforcements are required, the maximum differential pressure should be determined using ASME Section VIII, Division 1, Part UG-28.

17.2.3.5 Electrical Tests

The following tests shall be conducted:

- Ground grid and lightning protective grounds shall be tested, and adequate electrodes provided to assure the grounding system does not exceed 10 ohms to reference ground.
- Power conductors on 480-volt systems shall be insulation resistance tested in accordance with the National Electric Code (NEC), after installation but prior to being connected to any equipment.
- A resistance check shall be conducted on motors and equipment prior to connection of conductors.
- Insulated conductors rated above 600 volts shall pass appropriate high potential tests after installation in accordance with Insulated Cable Engineers Association (ICEA) and NETA Acceptance Testing Specification.

- A resistance check for instrument and control conductors shall be done conductor-to-conductor, conductor-to-ground, and conductor-to-shield where applicable. Wire-by-wire continuity and polarity tests shall be performed.

17.2.3.6 <u>Pre-Operational Tests</u>

The following shall be performed after construction tests have been completed to the satisfaction of the SPRPMO and instruments and controllers have been activated and calibrated.

- Equipment warranties shall be verified prior to pre-operational testing.

- Instrumentation loop tests shall be performed under simulated conditions to verify the components of the loop have been properly connected, checked out, calibrated, and adjusted, and are operating properly in accordance with approved procedures.

- All pumps shall be tested with clear, clean water for hydrostatic pressure, pumping capacity, discharge head and motor power usage in accordance with approved procedures.

- All electrical systems shall be operationally tested including all wiring, grounding devices, emergency power alarm signals, interlocks, and all other electrical devices.

- The contractor shall set and certify adjustment of all electrical relays and trips.

- The contractor shall remove, clean and re-install temporary strainers, or install new strainers prior to the test period.

- Check for alignment, dowel, and grout all machinery and drivers whenever possible. Make adjustments and realignment of all equipment under load or operating conditions.

17.2.3.7 Operational and Acceptance Tests

Site acceptance shall be determined through satisfactory performance of construction during fill, internal/external cycling, and drawdown exercises. Plans and procedures shall be developed in conjunction with the private sector as required to assure drawdown and fill objectives can be satisfied.

- No tests shall be conducted without procedures being submitted and test data collection forms approved by the SPRPMO.

- Prior to commencement of the operational tests, all construction tests, pre-operational and start-up tests shall have been completed and results approved by the SPRPMO.

- Systems test procedures will be written, approved by the PMO, and conducted that prove the entire installation meets requirements set forth in the design basis. As a minimum, the systems test shall demonstrate that the operation of the installation meets or exceeds established systems curves.

17.3 REQUIREMENTS – CAVERNS GENERAL CONSIDERATIONS – CAVERNS

The basic concerns for underground storage of crude oil are the structural integrity, tightness, and stability of the storage caverns. The ability to successfully meet specific design criteria in these three areas must be satisfied by the following requirements.

- The aggregate quality of the product withdrawn must be at least the same as the quality of the product stored, within allowable quality control limits.

- The volume of the product withdrawn must be the same as the volume of the product stored with allowances for surface wetting effects and traps.

- The above two requirements must be satisfied for the programmed life of the storage site.

17.3.1 SOLUTION MINED CAVERNS

The specific tests and evaluations for certification of a solution mined storage cavern (whether existing or newly created) are dependent upon a number of characteristics. The following shall be required.

- Sonar caliper cavern survey to determine the configuration and capacity.

- Well and cavern pressure test to determine the tightness of the cavern.

- Cement evaluation log to indicate the integrity of the cement bonding with the casing and the formation.

- Deviation survey to establish the tie-in point of the sonar caliper.

- Cavern pressures shall be in accordance with Chapter 2.

- Cased hole temperature logs.

- Safety inspections for operational readiness shall be conducted as required.

17.4 REQUIREMENTS - SOLUTION MINED CAVERNS

Existing caverns can be used whenever they meet the criteria for integrity, stability, recoverability, and tightness. There are four design criteria that shall be met before solution-mined salt caverns can be certified for storage. The design criteria are size, shape, spacing, and location in the dome. These are presented in detail in Chapter 2.

17.4.1 DRILLING TESTS

When drilling for new wells, the following tests and logs will be conducted as a minimum.

- During drilling obtain inclination surveys at intervals not to exceed 100 feet. Hole deviation shall be maintained within the following limits:

  a. Maximum allowable change in hole inclination is 1/2° per 100 feet.

  b. If 1/2° inclination is exceeded the interval will be reamed out to straighten the interval to < 1/2° inclination before drilling is resumed.

- During directional hole drilling, obtain inclination-azimuth directional surveys at intervals not to exceed every 100 feet of drilled wellbore. Hole deviation shall be maintained within the following limits:

  a. Maximum allowable dog leg severity is 3.0 degrees per 100 feet.

- During drilling operations run SP, IEL, G, RDC, CNL, CBL, caliper log, and gyroscopic multi-shot survey as required by site specific drilling prognosis or regulatory authority.

17.4.2 LOGS

The following casing logs are required:

17.4.2.1 Cement Evaluation or Bond Log

This log provides an indication of cement bonding quality with the casing and formation as a function of depth.

17.4.2.2 Density Log

A density log is required to verify hanging string depth.

17.4.3 CASING SHOE PRESSURE TEST

This test shall be conducted upon drill out of the innermost/production casing shoe. The test pressure at the casing shoe shall follow site specific lithostatic test requirements as set forth in Chapter 2 and state regulations.

17.4.4 SONAR SURVEYS

Sonar caliper surveys shall be taken throughout the leaching process to insure cavern geometry and spacing.

17.4.5 CERTIFICATION

Cavern and well certification tests shall be conducted in accordance with Level II Criteria.

17.5 REQUIREMENTS - BRINE DISPOSAL WELLS

The following tests shall be conducted in accordance with Louisiana Statewide Order 29-B or Texas Railroad Commission Rule 13:

- Annular pressure test.
- Injectivity test.

APPENDIX A

DOCUMENTS APPLICABLE

TO SPR DESIGN

APPENDIX A

DOCUMENTS APPLICABLE TO SPR DESIGN

The latest revision to the Strategic Petroleum Reserve (SPR) Performance Criteria - Level II and the standards and codes of the organizations listed in Appendix A, as of the date of design, shall be used.

In case of conflict between two or more applicable regulations, codes, or standards, the more stringent shall be used, or resolution shall be made by the SPR Project Management Office (SPRPMO) and identified in subordinate SPR documents and specifications.

All standards, codes, regulations, and statues of the organizations listed below shall be used where they are applicable to SPR design or operations. Listing of specific codes and standards are requirements emphasized for SPR.

- American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE)
  - ASHRAE Standard 62.1, Ventilation for Acceptable Indoor Air Quality
  - ASHRAE Handbook - HVAC Systems and Equipment
  - ASHRAE Handbook - Fundamentals
  - ASHRAE Handbook - HVAC Applications
  - ASHRAE Handbook - Refrigeration
- American Association of State Highway Transportation Officials (AASHTO)
  - AASHTO, A Policy on Geometric Design of Highways and Streets
- American Society of Civil Engineers (ASCE)
  - ASCE 7, Minimum Design Loads for Buildings and Other Structures
- American National Standards Institute (ANSI)

- ISO 100012-1, Quality Assurance Requirements for Measuring Equipment, Part 1: Metrological Confirmation System for Measuring Equipment

- ANSI A21.1, Thickness Design of Cast Iron Pipe

- ANSI B31.4, Pipeline Transportation Systems for Liquids and Slurries

- ANSI RP 12.6.01, Wiring Practices for Hazardous (Classified) Locations Instrumentation Part 1: Intrinsic Safety

- ANSI C2, National Electrical Safety Code

• American Petroleum Institute (API)

  - API Manual of Petroleum Measurement Standards (MPMS), Chapters 5 and 12, Appendix A (9-2)

  - API 5L, Specification for Line Pipe

  - API 6A, Wellhead and Christmas Tree Equipment

  - API 6D, Pipeline Valves, (Gate, Plug, Ball and Check Valves)

  - API 12F, Specification for Shop-Welded Tanks for Storage of Production Liquids

  - API-RP 14E, Paragraph 2.5.a, Design Installation of Offshore Production Platform Piping Systems

  - API SPEC 5CT, Specification for Casing and Tubing

  - API 14F, Design, Installation, and Maintenance of Electrical Systems for Fixed and Floating Offshore Petroleum Facilities for Unclassified and Class I, Division 1 and Division 2 Locations

  - API 500, Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Class I, Division 1 and 2

  - API 600, Steel Valves- Flanged and Butt-welding Ends, Bolted Bonnets

- API 602, Compact Steel Gate Valves- Flanged, Threaded, Welding, and Extended-Body Ends

- API 610, Centrifugal Pumps for Petroleum Petrochemical and Natural Gas Industries

- API 614, Lubrication, Shaft-Sealing, and Control Systems for Special Purpose Applications

- API 650, Welded Steel Tanks for Oil Storage

- API 670, Vibration, Axial Position, and Bearing Temperature Monitoring Systems

- API 671, Special Purpose Couplings for Refinery Service

- API 682, Shaft Sealing Systems for Centrifugal and Rotary Pumps

- API 1104, Welding of Pipelines and Related Facilities

- API-RP 541, Form Wound Squirrel Cage Induction Motors – 500 HP and Larger

- API-RP 546, Brushes Synchronous Machines – 500 kVA and Larger

- API-RP 545, Recommended Practice for Lightning Protection of Aboveground Storage Tanks for Flammable or Combustible Liquids

- API-RP 547, General Purpose Form Wound Squirrel Cage Induction Motors – 250 HP and Larger

- API-RP 1102, Liquid Petroleum Pipeline Crossing Railroads and Highways

- API-RP 1107, Recommended Pipeline Maintenance Welding Practices

- API-RP 1110, Pressure Testing of Liquid Petroleum Pipelines

- API RP 1115, Design and Operation of Solution-mined Salt Caverns Used for Liquid Hydrocarbon Storage

- API-2000, Venting Atmospheric and Low-Pressure Storage Tanks

- API-RP 2001, Fire Protection in Refineries

- API-RP 2003, Protection Against Ignitions Arising Out of Static, Lightning, or Stray Currents

- API-RP 2201, Procedures for Welding or Hot Tapping on Equipment Containing Flammables

• American Society of Mechanical Engineers (ASME)

  - ASME/ANSI B 16.1, Pipe Flanges and Fittings

  - ASME/ANSI B16.25, Butt Welding Ends for Pipe and Fittings

  - ASME B16.5, Steel Pipe Flanges and Flanged Fittings

  - ASME B16.10, Face-to-Face and End-to-End Dimensions of Ferrous Valves

  - ASME/ANSI, B16.9, Factory Made Wrought Steel Buttwelding Fittings

  - ASME/ANSI, B16.11, Forged Steel Fittings, Socket-Welded and Threaded

  - ASME/ANSI, B16.34, Valves – Flanged, Threaded and Welding End

  - ASME B31.3, Petroleum Refinery Piping

  - ASME B31.4, Liquid Transportation Systems for Hydrocarbons, Liquids Petroleum Gas, Anhydrous Ammonia and Alcohols

  - ASME B31.11, Slurry Transportation Piping System

  - ASME B73.1, Horizontal End Suction Centrifugal Pumps for Chemical Process

  - ASME Boiler and Pressure Vessel Code, and Interpretation:

    - - Section V, Article 7: Nondestructive Examination

    - - Section VIII, Division 1, Part UG-28: Rules for Construction of Unfired Pressure Vessels

    - - Section IX, Welding, Brazing and Fusing Qualifications

- American Society for Testing Materials (ASTM) Standard Specifications
- Construction Specification Institute
  - CSI Master-Format for Construction Specifications
  - Construction Specifications Writing: Principles and Procedures
- Federal Communications Commission (FCC) Rules and Regulations
- Factory Mutual (FM) Corporation
  - FM LPDS 4-1N, Fixed Water Spray Systems for Fire Protection
  - FM LPDS 4-5, Portable Extinguishers
  - FM LPDS 5-4, Transformers
  - FM LPDS DOT, Ignitable Liquid Storage Tanks
  - FM LPDS, Global Loss Prevention Data Sheets
- Illuminating Engineering Society of North America (IESNA)
  - ANSI/IES RP-7-17, Recommended Practice for Lighting Industrial Facilities
- Institute of Electrical and Electronic Engineers (IEEE)
  - IEEE Standard 998, Guide for Direct Lightning Stroke Shielding of Stations
  - IEEE Standard 142, Grounding of Commercial and Industrial Power Systems
  - IEEE Standard 242, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
- Instrument Society of America (ISA)
  - ISA-5.1, Instrument Symbols and Identification

- ISA-5.4, Instrument Loop Diagrams
- ISA RP12.06.01, Recommended Practice for Wiring Methods for Hazardous (Classified) Locations Instrumentation Part 1: Intrinsic Safety

- Insulated Cable Engineers Association (ICEA), Standards for Electrical Cable
- International Code Council (ICC), International Building Code (IBC)
- International Telecommunications Union (ITU) Recommendations for Telecommunications
- Manufacturers Standardization Society (MSS)
  - SP-44, Steel Pipeline Flanges
  - SP-75, Specifications for High Test Wrought Butt Welding Fittings
  - SP-80, Bronze Gate, Globe, Angle and Check Valves
- National Association of Corrosion Engineers (NACE) Standards for Corrosion Protection
- National Electrical Manufacturers Association (NEMA)
  - NEMA 250, Enclosures for Electrical Equipment (1000 Volts maximum)
  - NEMA ICS 3, Industrial Control and Systems: Medium Voltage Controllers Rated 2001 to 7200 Volts AC
  - NEMA MG-1, Motors and Generators
- ANSI/NETA ATS-2021 National Electrical Testing Association (NETA), Standards for Acceptance Testing Specifications for Electrical Power Equipment and Systems
- National Fire Protection Association (NFPA)
  - NFPA 12, Standard on Carbon Dioxide Extinguishing Systems
  - NFPA 15, Standard for Water Spray Fixed Systems for Fire Protection

  - NFPA 24, Installation of Private Fire Service Mains and Their Appurtenances
  - NFPA 30, Flammable and Combustible Liquids Code
  - NFPA 70, National Electric Code (NEC)
  - NFPA 75, Protection of Electronic Computer/Data Processing Equipment
  - NFPA 496, Standard for Purged and Pressurized Enclosures for Electrical Equipment
  - NFPA 497, Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous Locations for Electrical Installations
  - NFPA 780, Lightning Protection Systems
  - NFPA 90A, Air-Conditioning and Ventilation Systems
  - NFPA 101, Life Safety Code
  - NFPA 307, Construction and Fire Protection of Marine Terminals, Piers and Wharves
- National Standard Plumbing Code
- Underwriter's Laboratories, Inc. (UL) Standards
- State of Louisiana
  - Statewide Orders 29-B, 29-M
- State of Texas
  - Railroad Commission Rule 13, Casing, Cementing, Drilling, Well Control, and Completion Requirements
  - Railroad Commission Rule 9, Disposal Wells

- U.S. Government
  - Code of Federal Regulations
    - 29 CFR 1910, Occupational Safety and Health Standards
    - 29 CFR 1910 Subpart Z, 29CFR 1910.1450, OSHA Regulations, Toxic and Hazardous Substances, Occupational exposure to hazardous chemicals in laboratories
    - 33 CFR 154, Facilities Transferring Oil or Hazardous Material in Bulk
    - 33 CFR 156, Oil and Hazardous Material Transfer Operations
    - 33 CFR 320, Corps of Engineers Permit Requirements
    - 40 CFR 60, Subparts K, Ka, and Kb, Environmental Protection Agency, Air Programs, 41 CFR 101 Standards of Performance for Storage Vessels for Petroleum Liquids
    - 40 CFR 110, Environmental Protection Agency, Water Programs, Discharge of Oil
    - 40 CFR 112, Environmental Protection Agency, Water Programs Oil Pollution Prevention
    - 40 CFR 116, Environmental Protection Agency, Water Programs, Designation of Hazardous Substances
    - 40 CFR 122, Environmental Protection Agency, Water Programs EPA Administered Permit Programs: National Pollutant Discharge Elimination System (NPDES)
    - 40 CFR 125, Criteria and Standards for the National Pollutant Discharge Elimination System (NPDES)
    - 40 CFR 146, Environmental Protection Agency, Water Programs Underground Injection Control Program: Criteria and Standards
    - 40 CFR 227, Environmental Protection Agency, Ocean Dumping, Criteria for the Evaluation of Permit Applications for Ocean Dumping of Materials

- - 40 CFR, 302, Environmental Protection Agency, Superfund, Emergency Planning, and Community Right-to-Know Programs Designation, Reportable Quantities, and Notification

- - 40 CFR 230, Environmental Protection Agency, Ocean Dumping, Section 404(B)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material

- - 41 CFR 101, Federal Property Management Regulations

- - 49 CFR 195, Pipeline Safety Regulations, Transportation of Hazards Liquids by Pipeline

- Federal Acquisition Regulations (FAR), Part 157

- Congressional Acts

- - Federal Water Pollution Control Act (FWPCA), Pub. L. 86-70, 33 U.S.C. 1157 et seq.

- - Federal Water Pollution Control Act (FWPCA), Section 322

- - Federal Water Pollution Control Act (FWPCA), 33 U.S.C. 1344

- - National Environmental Policy Act, Pub. L. 91–190, 42 U.S.C. § 4321 et seq

- - Occupational Safety and Health Act

- - Resource Conservation and Recovery Act (RCRA), Pub. L. 94-580, 42 U.S.C. 6901 et seq.

- - Resource Conservation and Recovery Act (RCRA), Section 6001

- - Davis Bacon Wage Determination Act

- Executive Orders

- - Executive Order 11593, Protection and Enhancement of the Cultural Environment

- - Executive Order 11988, Floodplain Management and Subsequent Orders

- - Executive Order 11990, Protection of Wetlands and Subsequent Relevant Orders

- Department of Defense (DOD)

- - MIL-HDBK-217F, Reliability Prediction of Electronic Equipment
- - UFC-3-600-01

- Department of Energy (DOE/SPR)

- - DOE Standard 1066-2016, Fire Protection

- - DOE Order O 413.3B, Program and Project Management for the Acquisition of Capital Assets

- - DOE Order O 420.1C, Chg. 3, Facility Safety

- - SPRPMO O 430.1C, Reliability, Availability and Maintainability Program

- - SPRPMO O 410, SPR Configuration Management Program

- - DOE 470 (Series)

- - DOE Order 470.4B Change 3, Safeguards and Security Program

- - DOE Order 422.1, Chg. 3, and SPRPMO O 420.1E, Conduct of Operations

- - SPRPMO O 470.4B, Security and Emergency Preparedness Order

- - Site Security Plan (SSP) Classified

- - SPR Integrated Logistics Support Master Plan

- - SPRPMO Manual M 450.1-1B, SPR Environmental, Safety and Health Manual

- - DOE G 413.3-7A, Chg. 1, Risk Management Guide

- -- DOE G 413.3-21A, Cost Estimating Guide
- -- SPR Environmental Impact Statements (EIS) or Environmental Assessments (EA)
- -- Spill Prevention Control and Countermeasures Plan (SPCC), Site Specific BCL5400.16, BHL5400.21, BML5400.17, WHL5400.20
- -- MS-U-901-002, Project Performance Criteria Level II
- -- MS-I-910-006, Control System Functional Specification
- -- MS-PP-910-001, Multisite Security Functional Specification
- -- SPR Standard Specifications

- Federal Aviation Administration (FAA)
  - -- AC 150/5390-2C, Heliport Design
  - -- AC 70-7640-1M, Obstruction Marking and Lighting
- Federal Specifications
  - -- W-A-450-C, Alarm Systems, Protective and Interior
- General Services Administration (GSA)
  - -- GSA Catalog of Physical Security Systems
- National Telecommunications and Information Administration (NTIA) Manual, Chapter 5, Spectrum Standards