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API
RECOMMENDED PRACTICE
FOR
PLANNING, DESIGNING,
and CONSTRUCTING
FIXED OFFSHORE PLATFORMS

OFFICIAL PUBLICATION



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Foreword

This *Recommended Practice for Planning, Designing, and Constructing Fixed Offshore Platforms* contains engineering design principles and good practices that have evolved during the development of offshore oil resources. Good practice is based on good engineering; therefore, this recommended practice consists essentially of good engineering recommendations. In no case is any specific recommendation included which could not be accomplished by presently available techniques and equipment. Consideration is given in all cases to the safety of personnel, compliance with existing regulations, and pollution of water bodies.

Offshore technology is growing rapidly. In those areas where the committee felt that adequate data were available, specific and detailed recommendations are given. In other areas general statements are used to indicate that consideration should be given to those particular points. Designers are encouraged to utilize all research advances available to them.

As offshore knowledge continues to grow, this recommended practice will be revised. It is hoped that the general statements contained herein will gradually be replaced by detailed recommendations.

DEFINITIONS

FIXED STRUCTURE —	A structure extending above and supported by the seabed by means of piling, spread footings or other means with the intended purpose of remaining stationary over an extended period.
MANNED STRUCTURE —	A structure which is actually and continuously occupied by persons accommodated and living thereon.
UNMANNED STRUCTURE —	A structure upon which persons may be employed at any one time, but upon which no living accommodations or quarters are provided.
OPERATOR —	The person, firm, corporation or other organization employed by the owners to conduct operations.
ASCE —	American Society of Civil Engineers
ASME —	American Society of Mechanical Engineers
AIEE —	American Institute of Electrical Engineers
ASTM —	American Society for Testing Materials
API —	American Petroleum Institute
AWS —	American Welding Society
AISC —	American Institute of Steel Construction
NFPA —	National Fire Protection Association
AAODC —	American Association of Oilwell Drilling Contractors
SSPC —	Steel Structures Painting Council

NOTE: This is the 1st edition of this *Recommended Practice*. It is under the jurisdiction of the API Committee on Standardization of Offshore Structures and was authorized for publication at the 1969 meeting, as detailed in Circ PS-1377.

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RECOMMENDED PRACTICE FOR PLANNING, DESIGNING, AND CONSTRUCTING FIXED OFFSHORE PLATFORMS

SECTION 1

PLANNING

PLATFORM CONSIDERATIONS

1.1 General

a. This section serves as a guide for those who are concerned with the design and construction of platforms for drilling, developing and storage of hydrocarbons in offshore areas. Adequate planning should be done before actual design is started in order to obtain a workable and economical offshore platform to perform a given function. The initial planning includes the determination of all criteria upon which the design of the platform will be based.

b. Design criteria as used herein includes all operational requirements and environmental data which could affect the detailed design of the platform.

c. This publication has incorporated and made maximum use of existing codes and standards which have been found acceptable for engineering design and practices from standpoint of public safety.

1.2 Operational

a. **Function.** The function for which a platform is to be designed must be known. These functions are usually categorized as drilling, producing, storage, materials handling, living quarters, or some combination of these. The platform configuration can be determined by layouts of equipment to be located on the decks. Careful consideration should be given to the clearances and spacing of equipment before the final dimensions are decided upon.

b. **Location.** The location of the structure must be specific before the design is completed. Environmental conditions vary with geographic location, and within a given geographic area the foundation conditions will vary as will such parameters as design wave heights, periods and tides.

c. **Orientation.** The orientation of the structure refers to its position in plan referenced to a fixed point such as true north. Orientation is usually governed by the direction of prevailing winds, currents, or operational requirements.

d. **Water Depth.** The water depth and tides are needed to select appropriate oceanographic design parameters. The water depth should be determined as accurately as possible so that elevations can be established for boat landings, fenders, and the deck.

e. **Access and Auxiliary Systems.** The location and number of stairways and access boat landings to the platform should be governed by safety considerations. A minimum of two accesses to each manned level should be installed, and they should be located so that escape is possible under varying wind conditions. Operating requirements should also be considered in stairway locations.

f. **Fire Protection.** The safety to personnel and possible destruction of equipment requires serious attention to fire protection methods. The selection of the system depends upon the function of the platform. Procedures should conform to all Federal, State and local regulations where they exist. In the U.S.A. refer to: *Rules and Regulations for Artificial*

Islands and Fixed Structures on the Outer Continental Shelf, CG-320 as published and available from the U.S. Coast Guard. Guidance can also be obtained from the latest edition of the *Manual of Safe Practices in Offshore Operations*, published by the Offshore Operators Committee.

g. **Deck Elevation.** The elevation of the lower deck of a platform should provide adequate clearance above the crest of the design wave. Consideration should be given to providing a generous air gap to allow the passage of freak waves larger than the design wave. The clearance between decks is governed by operational restrictions and these should be known before the design is completed.

h. **Wells.** Where the platform under consideration is to be a drilling platform or a well protector, information about wells to be incorporated into the platform must be known. Conductor pipes will add additional wave load to the structure and may or may not assist in resisting the wave force. If the platform is to be set over an existing well with the wellhead above water, information is needed on the dimensions of the tree, size of conductor pipe, and the elevations of the casing head flange and top of wellhead above mean low water. If the existing well is a temporary subsea completion, plans must be made for locating the well and setting the platform properly so that the well can later be extended above the surface of the water.

For future wells that are to be drilled from the platform, the number, configuration, spacing and size of conductor pipe to be used are all required.

i. **Equipment and Material Layouts.** Layouts and weights of drilling equipment and material and production equipment are needed prior to beginning the design. It is necessary to locate the heavy concentrated loads on the structure so that proper framing for supporting these loads can be planned for the deck section. These layouts should be planned by operating personnel and the engineering staff. Insofar as is known, considerations should be given to future operations.

j. **Personnel and Material Handling.** Plans for handling men and materials should be known prior to the start of the platform design, as well as the type and size of supply vessels and the anchorage system required to hold them in position at the platform. The number, size and location of the boat landings are needed. The type, capacity, number and location of the deck cranes should be determined. If equipment or materials are to be placed on a lower deck, then adequately sized hatches conveniently located may be desirable on the upper deck. This information should also be obtained from operating personnel.

k. **Spillage and Contamination.** Provision for handling spills and potential contaminants should be provided. A deck drainage system which collects and stores for subsequent handling will be helpful in preventing contamination of surrounding waters. In no case will the drainage and collection system be less than that required by the appropriate governmental regulations.

1.3 Environmental

a. Meteorological. Forces are exerted by wind on that portion of the structure above the water as well as the equipment on the platform. The wind velocity which creates the force may be classified as either: (1) gusts which are intermittent in action with varying periods of occurrence and duration, or (2) sustained, which is the steady wind speed which varies little in its intensity.

The sustained wind velocity is used where storms are classified by the intensity of the wind velocity. The sustained wind velocity is one which prevails for periods longer than 5 minutes at a time and recurs several times during a storm.

b. Oceanographic. Wind-driven waves during a storm are a source of forces acting on structures built in the sea. Wave forces are difficult to determine both as to intensity and in application. The waves are of an infinite number of shapes and sizes and can approach the structure from any direction and often from more than one direction simultaneously. Because of the technical nature of the factors which must be considered in arriving at wave criteria which can be used in the design of an offshore platform, an experienced oceanographer should be consulted regarding the wave parameters to be applied in the design.

Tides are important considerations in platform design. Tides may be classified as: (1) Lunar or astronomical tide, (2) wind tide, and (3) pressure differential tide. The sum of these three tides is called the storm tide. In the design of a fixed offshore structure, the storm tide elevation is the datum upon which storm waves are superimposed. The variations in elevations of the daily lunar tides, however, determine the elevations of the boat landings, barge fenders and the splash zone treatment of the steel members of the structure.

Currents are important in the design of fixed platforms as they affect: (1) the location and orientation of boat landings and barge bumpers, and (2) the forces on the platform. Boat landings and barge bumpers should be located, where possible, to allow the boat to come against the platform as it moves into the current. Current velocity should be considered when computing the total hydrodynamic forces acting on the structure.

c. Ice. In some areas where petroleum development is being carried out, very low, freezing temperatures prevail a major portion of the year. Ice, in the form of fields of floating, grinding packs, moving back and forth on the tidal currents which ebb and flood, produce formidable design problems.

Ice criteria are in the initial stages of development. Total ice forces vary depending on such factors as severity of the winters, location of platform, size and configuration of platform, and unit ice strength. Unit ice forces depend on temperature, speed of application, composition of the ice and other factors. Forces to be used in design should be determined in conjunction with qualified experts. To reduce forces and the possibility of local damage, a platform configuration should be selected which limits the number of elements in the ice zone. Appropriate steels for use in low temperatures should be selected.

d. Earthquakes. Seismic forces should be considered in platform design in those areas of petroleum development where earthquakes are an ever-present possibility. Forces in the structure result from the ground motion caused by the earthquake. Methods for evaluating and predicting earthquake motions as

well as methods for analyzing structures subject to earthquake loads are continually being improved. Present building code formulae require structures to be designed to resist static forces proportional to the mass of the structure. A more rigorous method of analysis would be a complete dynamic analysis of the structure.

e. Scour. Scour is produced on the sea bottom whenever a structure of any shape is placed on bottom in an area where currents of sufficient velocity exist. These currents, when diverted by the obstruction, create whirling eddies. These eddies in turn wash away the loose materials of the sea bottom and create a scoured out, bowl-shape depression around the obstruction. Structures, where scour is a possibility, should receive special consideration during the design.

f. Marine Fouling. In the tropic and semi-tropic oceans of the world fouling of all structures built in the sea is an ever-present problem. Marine growth is confined more or less to the zone of light infiltration, and limited air entrapment. This growth may be strong enough to create added wave resistance and should be considered where necessary.

g. Foundations. Knowledge of the foundation conditions existing at the site of construction of any sizable structure is necessary to produce a safe and economical design. On-site soil investigation should develop information as to the bearing and pull-out capacity of different diameters of piling at increasing penetrations, as well as the lateral resistance of such piling. Information as to the contour of the bottom is important. It should be determined if the bottom is soft or sandy, and if currents exist. Large boulders, rocky shelves or other objects on bottom should be plotted.

PLATFORM CLASSIFICATION

1.4 Classification of Platforms

a. General. Platforms installed according to these recommended practices shall be classified according to the severity and frequency of the environmental loads imposed thereon. The classification system set out herein shall be used in order to establish a recognized system for establishing the design strength of the platform.

b. Class Number. The class number shall be defined as the reciprocal of the probability of the design environmental conditions being equalled or exceeded at the specific platform site (as opposed to the entire geographical region) during any one-year period. For example, a class 100 platform would be designed to resist environmental loads which correspond to a one percent annual probability while class 25 would correspond to four percent annual probability.

These examples do not preclude the use of other classes. Also, a given platform may have different classifications for different types of environmental conditions. For example, a platform may be class 50 for ice loading, but class 200 for earthquake. Similarly, if the same platform design is used in several different regions, the classifications may be different for each location.

1.5 Selecting the Class of Platforms. Selection of the class to which platforms are designed shall be the prerogative of the owner. Factors to be considered include the following:

a. Probability of personnel being quartered on the platform.

b. Prevention of possible pollution.

c. Intended use of the platform.

d. Planned life of the platform.

e. Cost of the platform, giving consideration to both initial cost and estimated losses if the design criteria is exceeded.

In general, a high classification (low probability) is appropriate where the design event may occur while the platform is manned and strike without warning. Economic risk evaluations for offshore platforms have indicated that the optimum class number is several times the planned life in years.

1.6 Platform Types. The different types of fixed offshore platforms may be categorized as follows:

a. **Template.** A template-type platform consists of:

1. The jacket or welded tubular space frame which is designed as a template for pile driving, and to serve as lateral bracing for the piles.
2. Piling which permanently anchor the platform to the ocean floor, and serve to carry both lateral and vertical loads.

3. A superstructure consisting of the necessary trusses and deck space for supporting operational and other loads.

b. **Tower.** A tower platform is one which has relatively few large diameter (fifteen-foot range) legs. The tower may be floated to location and placed in position by selective flooding.

Tower platforms may or may not be supported by piling. Where piling are used, they are driven through each leg of the tower into the soil foundation to support the platform. The piling may also serve as well conductors. Where the tower depends on bearing rather than piling for support, the well conductors may be installed either in or outside the legs.

c. **Caisson.** A caisson platform is one whose foundation support consists of one large member. These structures range from free-standing caissons which support only one well (i.e., 30 in. OD) to large structures tens of feet in diameter.

d. **Others.** Other structures, such as underwater oil storage tanks, bridges connecting platforms, etc., would be covered by these specifications only to the extent to which they are applicable.

SECTION 2

DESIGN PROCEDURES FOR FIXED OFFSHORE PLATFORMS

GENERAL

2.1 Dimensional System. All drawings, calculations, etc., should be consistent in one dimensional system, such as the English dimensional system.

2.2 Definition of Loads.

a. **Dead Weight.** The dead weight shall be the air weight of the platform, including piling, superstructure, template, stiffeners, piping, anodes, decking, etc.

b. **Buoyancy.** Buoyancy shall be calculated on the basis of the platform displacement to the design waterline, with deductions for flooded parts of the structure.

c. **Drilling Equipment Weight.** Drilling equipment weight shall be the weight of drilling equipment placed on the platform, including such items as: derrick, draw works, mud pumps, mud tanks, etc.

d. **Production Equipment Weight.** Production equipment weight shall be the weight of production equipment which includes: separators, compressors, production manifolds, etc.

e. **Drilling Supply Weights.** Drilling supply weight shall be the weight of variable loads during drilling, such as: mud, water, diesel fuel, casing, etc.

f. **Production Supply Weight.** Production supply weight shall be the weight of variable supplies during production, such as: fluid in the separator, storage in the tanks, etc.

g. **Drilling Load.** The drilling load shall consist of any appropriate combination of derrick corner load, set-back, or rotary load.

h. **Dynamic Forces.** Dynamic forces, which act in addition to the applied loads taken statically shall include due consideration of the following:

1. Dynamic amplification of cyclic forces which excite the platform (or some component) at or near its natural frequency.
2. Impact from loads that are suddenly or dynamically applied. These are often designated as a given factor times the applied load.

i. **Installation Loads.** Installation loads are those loads that are experienced during platform construction. They generally are forces that occur during loading out, launching, or lifting operations.

j. **Environmental Loads.** Environmental loads shall consist of those loads imposed on the platform by adding all the environmental forces to which the platform is simultaneously subjected. Design load combinations shall be consistent with the probability of occurrence as defined in Par. 1.5 compared to the maximum condition that could occur.

Loads to be considered are:

1. Wave force
2. Current force
3. Wind force
4. Ice force
5. Earthquake force

2.3 Direction of Environmental Forces. Environmental loads may be considered as coming from only those directions which are possible as consistent with the given level of probability as defined in Par. 1.5 and with the anticipated tolerance in orientation of the structure.

DESIGN LOADING CONDITIONS

2.4 Loading Conditions

a. **Minimum Loading Conditions.** The platform shall be designed and checked under a minimum of five assumed loading conditions. These conditions are:

1. Design environmental conditions with appropriate drilling loads.
2. Operating environmental conditions during drilling operations.
3. Design environmental conditions with appropriate producing loads.
4. Operating environmental conditions during producing operations.

5. Design environmental conditions with minimum loads on the platform.

b. **Definitions.** Design environmental conditions are those forces imposed on the platforms by the selected design event; whereas, operating environmental conditions are those forces imposed on the structure by a lesser event which is not severe enough to restrict normal operations, as specified by the operator.

2.5 Individual Member Loadings.

Each individual member shall be designed for that load or combination of loadings which produce the maximum stress for that member.

DESIGN LOADS

2.6 Waves.

a. **Design Wave Parameters.** The design wave for a platform is described by the parameters of wave height, wave period, wave length and still water depths. The values of these parameters to be used shall be determined by qualified personnel. The values selected shall be consistent with the classification of the structure.

b. **Wave Force on a Member.** The horizontal force exerted by waves on a cylindrical object consists of a drag force which is related to the kinetic energy of the water and an inertia force which is related to the acceleration of the water particle. This force is given by

$$F = F_D + F_I = C_D \frac{w}{2g} D U |U| + C_m \frac{w}{g} \frac{\pi}{4} D^2 \frac{dU}{dt} \dots (1)$$

where:

- F = wave force per foot of length acting perpendicular to the member, lb/ft
- F_D = drag force per foot of length, lb/ft
- F_I = inertia force per foot of length, lb/ft
- C_D = drag coefficient
- w = weight density of water, lb/ft³
- g = gravitational acceleration, ft/sec²
- D = diameter of cylindrical member, ft
- U = horizontal particle velocity of the water, ft/sec $|U|$ = absolute value of U
- C_m = mass coefficient
- $\frac{dU}{dt}$ = derivative of U with respect to time, i.e., horizontal acceleration of the water particle, ft/sec²

The proper values of C_D and C_m depend in part on the wave theory being used. Thus, set values for all conditions cannot be given. Typical values will range from 0.5 to 1.0 for C_D and from 1.3 to 1.7 for C_m . The values selected should not be smaller than the lower limits of these ranges.

The water particle velocity, U , is a function of wave height, wave period, water depth, distance above bottom and time. No presently available theory completely represents this function, although various theories approximate it for certain value ranges of the parameters involved.

c. **Wave Position Relative to Structure.** The wave crest should be positioned relative to the structure so that the wave forces have their maximum effect on the structure as a whole. Maximum stress in a locally sensitive portion of the structure may occur for a wave position, height, or period other than that causing maximum total force on the structure as a whole.

2.7 Wind.

- a. **General.** The velocity of the wind to be used

in design shall be determined by appropriate means. The velocity selected shall be consistent with the risk assumed for the structure.

b. **Wind Velocity and Force Relationship.** The wind force on an object shall be calculated by using an appropriate method. One such method is:

$$F = 0.00256(V)^2 C_s A \dots (2)$$

where:

- F = wind force, lb
- V = sustained wind velocity, mph at elev. + 30 ft
- C_s = shape coefficient
- A = projected area of object

c. **Direction of Wind Force.** For all angles of wind approach to the structure, forces on flat surfaces act normal to the surface; forces on cylindrical tanks, pipes, and other cylindrical objects act in the direction of the wind.

d. **Shape Coefficients.** The following shape coefficients (C_s) are recommended for all angles of wind approach.

- Beams 1.5
- Sides of buildings 1.5
- Cylindrical sections 1.0

e. **Shielding Coefficients.** Shielding coefficients may be used when, in the judgment of the designer, the second object lies close enough behind the first to warrant the use of the coefficient.

2.8 Current.

a. **General.** The velocity of the current to be used in design shall be determined by appropriate means. The velocity selected shall be consistent with the procedure used to select the design parameter for the structure.

b. **Current Variation with Depth for Shallow Channels.** In the absence of field data, the current shall vary with depth in accordance with the following:

$$V_x = V_s \left(\frac{X}{d} \right)^{1/7} \dots (3)$$

where:

- V_x = current velocity (fps) at distance X (feet) above mud line
- V_s = current velocity (fps) at water surface
- X = distance (feet) above mud line
- d = distance (feet) from water surface to mud line

c. **Current Variation with Depth in Open Waters.** Qualified personnel should determine the variations of current velocity with depth as well as the variation of direction of flow for the area of open water in question.

d. **Current Force Only.** Where current is acting alone (i.e., no waves) the force shall be given by:

$$F_L = 0.5 C_L \rho V^2 A \dots (4)$$

$$F_D = 0.5 C_D \rho V^2 A \dots (5)$$

where:

- F_L = lift force per unit length
- F_D = drag force per unit length
- C_L = lift coefficient
- C_D = drag coefficient
- ρ = mass density
- V = current velocity, fps
- A = projected area per foot of length

C_D and C_L shall be based on best information available for the current velocity and type of structural member involved. For long cylindrical members with

large length-diameter ratios, the lift force may be critical and should be checked in the design.

e. **Current Associated with Waves.** Due consideration should be given to the possible superposition of current and waves. In those cases where this superposition is deemed necessary, the current velocity should be added vectorially to the wave particle velocity before the total force is computed.

f. **Current Induced Flutter.** All symmetrical members exposed to the current should be investigated for the possibility of flutter due to von Karman vortex shedding.

2.9 Ice

a. **General.** The thickness and strength of the ice as well as the velocity at which ice will strike the platform must be determined for all areas where the ice hazard exists.

b. **Ice Force.** Ice shall be assumed to exert a force on a structure equal to:

$$F = C f_c A \quad (6)$$

where:

F = ice force, lb

C = coefficient

f_c = compressive strength of ice, psi

A = area struck by ice, in²

Ice strength, f_c , varies with temperature, salt content, load rate, etc. However, values in the range between 200 psi and 500 psi may be expected. The coefficient, C , depends on shape, speed of application, etc., and will range between 0.3 and 0.7. The values used for design should be determined by appropriate means and should be consistent with the design class of the structure.

2.10 Earthquake

a. **General.** The characteristics of strong earthquake motions are known only in a statistical sense; and as a result, rational techniques of designing earthquake-resistant structures must cope essentially with the statistical nature of the problem. Geographical locations and time of future earthquakes are unknown except in a statistical manner, and the ground motion can be specified only in terms of average spectra, assuming that earthquakes will occur. In earthquake-resistant design there are two fundamental decisions which must be made: (1) an assessment of the probability of occurrence of potentially dangerous earthquakes and (2) an evaluation of structural response spectra for earthquake excitations crucial to the structure itself on the basis of rational dynamic analysis.

b. **Uniform Building Code.** Design criteria for earthquake are variable, depending upon the seismicity of the platform site. Seismicity is a measure of the past earthquake activity for the area. Within the contiguous 48 states, the seismicity is best represented by the Seismic Probability Map of the United States in the *Uniform Building Code, Vol. 1*, of the International Conference of Building Officials. This map places these states into earthquake zones 0, 1, 2, and 3.

The *Uniform Building Code* provides basic design criteria for Zone 3, with multiplying factors of $\frac{1}{2}$, $\frac{1}{4}$, and 0 for zones 2, 1, and 0, respectively. It is clear that Zone 0 calls for no earthquake design, with lateral forces due to wind and wave to govern the design. In other zones, while earthquake forces need to be evaluated, other lateral force criteria may exceed those stipulated for earthquake design. Therefore the controlling lateral force criteria may be earthquake (without wind or wave), or wind + wave

+ current, or ice + wind + current, as appropriate to the site of the platform.

The following method is offered as an alternate in lieu of a rational analysis as discussed in Section 2.10a. As a minimum, structures designed for earthquakes should satisfy the requirements of the *Uniform Building Code*.

The *Uniform Building Code* criteria for earthquake forces is given by the equation for the base shear, V

$$V = Z K C W \quad (7)$$

where

V = base design shear, in kips

Z = zone or seismicity factor = 1.0 for Zone 3

K = structure-type factor, which for offshore platforms should not be less than 2.00

C = flexibility factor = $0.05/T^{1/3}$

W = weight of the structure, kips

T = calculated natural period of the structure, sec

Some further explanation of these terms that define the base shear is in order. W should include the normal load on the platform during the drilling period. It should include the masses or weights of water included in tubular members, plus the weight of the water displaced by the submerged members. This weight should also be used in calculating the fundamental natural period of vibration of the structure, T , by recognized dynamic methods. In this set of criteria, T is used exclusively for the purpose of determining C . However, offshore platforms do not have noncomputed resistances typical of most buildings. Hence, it is stipulated that platforms be designed for not less than $K = 2.00$ in combination with normal drilling loads and virtual masses of the submerged portion of the platform, in addition to dead loads. Moreover, due consideration should be given to the mass concentration at the top of the platform and the localized forces in portions of the structure influenced thereby.

The base shear should be distributed to the masses of the structure and its appurtenances in accordance with the criteria specified in the *Uniform Building Code*. The analysis of the structure for the combination of vertical and lateral forces of earthquake shall result in stresses no greater than 1.33 times basic allowable stresses as given herein.

INSTALLATION FORCES

2.11 **General.** Installation forces are those forces imposed upon the separate component parts of the structure during the operations of moving the components from their fabrication site to the offshore location, and installing the component parts to form the completed structure. Since installation forces involve the motion of heavy masses, the dynamic loading involved should be considered and the static forces increased by appropriate impact factors to arrive at adequate equivalent loads for design of the members affected.

2.12 Lifting Forces

a. **Horizontal and Vertical Components.** Lifting forces on padeyes and on internal members of the structure may include both vertical and horizontal components. Horizontal components of lifting forces result from the inclination to the vertical of the lifting slings. The sum of the vertical components of lifting forces will be equal to the total net weight of the lift after accounting for the buoyancy of that part of the structure which is submerged.

b. **Static Equilibrium.** When lifted, the lift will swing into a position such that the center of gravity

of the lift and the centroid of all upward acting vertical forces on the lift are the static equilibrium. Upward forces on the lift would include buoyancy and the lifting load on the hook of each piece of equipment making the lift. The position of the lift in this state of static equilibrium shall be taken into account in determining the angle of inclination to the vertical of the lifting slings. The movement of the lift as it is picked up and set down shall be taken into account in determining horizontal forces at points other than attachment of the lifting slings.

c. **Load Factors.** For the design of padeyes and the design of the connections of padeyes to the structure, a minimum load factor of 2.0 shall be used. A similar load factor shall be used for the design of those internal members of the structure connected directly to the padeyes and transmitting lifting forces within the structure. In this paragraph, load factor is defined as the ratio of capacity at allowable stress, to the applied static load.

2.13 Loadout Forces

a. **Direct Lift.** Lifting forces for a structure loaded out by direct lift onto the transportation barge need be evaluated only if the lifting arrangement differs from that to be used in the installation, since lifting in open water will impose more severe conditions. Support forces from the supports, cradles, or ways on the barge will generally be governed by transportation in open water.

b. **Horizontal Movement Onto Barge.** Structures moved horizontally onto the transportation barge by means of ways or by wheeled dollies on tracks supported by cribbing shall be checked for the effects of localized loading resulting from the change in slope of the ways or tracks and the change in draft of the transportation barge as the weight of the structure moves onto it. Since movement is normally slow, impact need not be considered. Support forces on the transportation barge will generally be governed by transportation in open water.

2.14 **Transportation Forces.** Horizontal and vertical forces acting on a structure from its supports on the transportation barge shall be determined considering the height, length, and period of waves which may be encountered during tow, the dimensions and dynamic characteristics of the loaded barge, and the dimensions, center of gravity and total weight of the structure considered.

2.15 Launching Forces

a. **Template Type.** Those jackets of template type structures which are launched are usually launched from the transportation barge at or near the installation location. The jacket is generally moved along ways, which terminate in rocker arms, on the deck of the barge. As the position of the jacket reaches a point of unstable equilibrium, the jacket rotates, causing the rocker arms at the end of the ways to rotate as the jacket continues to slide from the rocker arms. Forces supporting the jacket on the ways should be evaluated for the full travel of the jacket. Deflection of the rocker beam and the effect on loads throughout the jacket is an important consideration. In general, the most severe forces will occur at the instant rotation starts. Horizontal forces required to initiate movement of the jacket should also be evaluated.

b. **Tower Type.** Tower type structures are generally launched from the fabrication yard to float with their own buoyancy for tow to the installation site. The last portion of such a jacket leaving the launching ways may have localized forces imposed on it as the first portion of the jacket to enter the

water gains buoyancy and causes the jacket to rotate from the slope of the ways. Forces should be evaluated for the full travel of the jacket down the ways.

2.16 Uprighting Forces

a. **Hook Load.** Floating jackets for which lifting equipment is employed for turning to a vertical position shall be checked for the lifting forces required to upright the jacket. Inertial forces due to the entire mass constrained to move with the barge should be considered.

b. **Submergence Pressures.** The non-flooded members of the jackets shall be checked for collapse due to external pressure at their maximum submergence.

2.17 **Installation Bearing Pressure on Soil.** The installation bearing pressure on the soil at the location should be evaluated to determine that the structure may be installed at the proper elevation. The installation pressure on those portions of the structure which are to be embedded in the bottom should be sufficient to permit this embedment, or supplementary means of penetration such as jetting systems should be employed. The installation pressure on the area of the structure at the mud line should be sufficiently low so that the structure will remain substantially at planned location until piles are driven. Members stressed by installation pressures shall be designed for such forces.

ALLOWABLE STRESSES FOR STRUCTURAL STEEL

2.18 General

a. **Basic Stresses.** Unless otherwise noted, the platform shall be designed so that all members are proportioned for basic allowable stresses specified by the AISC "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings", latest edition. Where the structure element or type of loading is not covered by AISC, a rational analyses shall be used to determine the basic allowable unit stresses with factors of safety equal to those of AISC.

b. **Increased Allowable Stresses.** Where stresses are due in part to the lateral and vertical forces imposed by design environmental conditions, the basic AISC allowable stresses may be increased by one-third. Moreover, the required section properties computed on this basis shall not be less than that required for design dead and live load and impact computed without the one-third increase.

2.19 **Local Buckling.** Unstiffened tubular members should be investigated for local buckling when:

$$\frac{D}{t} > \frac{E}{12F_y} \dots \dots \dots (8)$$

where:

D = mean diameter

t = wall thickness

E = modulus of elasticity of material

F_y = yield stress of material

2.20 Fatigue Stresses

a. **Members and Connections Subject to Repeated Variations of Stress.** Where the repetitions of stress are of a known, cyclic nature — such as filling and emptying of tanks, crane usage, machinery vibration, or wave load, the allowable design stresses for fatigue loading as defined by the AISC will apply.

b. **Effect of Salt Water.** Due consideration should be given to the effects of salt water corrosion, especially at the interface between air and water.

c. **Fatigue and Brittle Fracture.** In the design of tubular joints due consideration should be given to the problems of high stress—low cycle fatigue and brittle fracture.

2.21 **Slenderness Ratio.** The determination of the slenderness ratio of an axially loaded compression member shall be according to the AISC. For deck legs framing into a truss at each end and subject to sideway, K may be taken as 2.0 in lieu of rational analysis.

2.22 Connections

a. **Connection of Tension and Compression Members in Trusses.** The connections at ends of tension or compression members of trusses shall develop the strength required by stress, but not less than 50% of the effective strength of the member. Groove welds in connections at the ends of tension members in trusses shall be complete penetration.

b. **Restraint and Shrinkage.** Details shall be such as to minimize constraint against ductile behavior, to avoid undue concentration of welding, and to afford simple access for the placing of weld metal.

Joints shall be designed so as to minimize, insofar as practicable, stresses due to the contraction of the weld metal and adjacent base metal upon cooling.

c. Tubular Joints.

1. Design and detailing of tubular joints shall be in accordance with good current practice.
2. Simple joints (i.e., those without significant overlap or eccentricity, and having no gussets, diaphragms or stiffeners) should be proportioned so that shear stress on a potential failure surface in the chord wall is consistent with available test results.
3. Complex joints for which neither elastic theories nor test data are available should be checked for adequate static strength to carry the design load. This check may be done by cutting sections which isolate groups of members, individual members, and separate elements of the joint (e.g., gussets), and verifying that a distribution of stress can be found that satisfies equilibrium without exceeding the yield strength of the material. Model testing of the joint may be done in preference to such approximate analysis.

2.23 **Hydrostatic Collapse.** Due consideration shall be given the interaction of stresses due to hydrostatic pressure on submerged members, and stresses due to other loads on the platform.

2.24 **Deflections.** Consideration shall be given to the effect of deflections on the distribution of load between the platform and supported rigid equipment packages.

ALLOWABLE SOIL STRESS

2.25 **General.** In the absence of reliable comprehensive data which would support the use of other values for determining foundation capabilities, the limiting values given herein shall be used.

2.26 Pile Capacity for Axial Bearing Loads

a. **Ultimate Bearing Capacity.** The ultimate bearing capacity Q_d shall be resolved by the equation:

$$Q_d = Q_f + Q_p = fA_s + qA_p \quad (9)$$

where:

Q_f = skin friction resistance
 Q_p = total point resistance
 f = unit skin friction capacity
 A_s = side surface area of pile
 q = unit end bearing capacity
 A_p = gross end area of pile

qA_p should not exceed the capacity of the internal plug

b. **Skin Friction and Point Resistance in Clay.** For piles driven through clay f may be equal to or less than but shall not exceed the undrained shear strength of the clay, c , as measured by unconfined compression tests or miniature vane tests on undisturbed soil samples in accordance with ASTM specifications.

Unless test data indicates otherwise, for soil penetrations less than 100 feet, f shall not exceed $\frac{1}{2}$ ton per square foot. For soil penetrations greater than 100 feet, f shall not exceed $\frac{1}{3}$ of p_o where p_o is the effective overburden pressure of the soil. For jetted or drilled-in piles in clay, f shall be reduced by some reliable method based on the amount of soil disturbance from installation, but f shall not exceed values given for driven piles.

For piles end bearing in clay, q shall be equal to $9c$.

c. **Skin Friction and Point Resistance in Sand and Silt.** For piles driven through sand or silt, f shall be computed by the equation:

$$f = K p_o \tan \phi' \quad (10)$$

where:

K = coefficient of lateral earth pressure
 p_o = effective overburden pressure
 ϕ' = angle of soil friction on pile wall

For piles end bearing in sand or silt, q shall be computed by the equation:

$$q = p_o N_q \quad (11)$$

where:

N_q = bearing capacity factor.

The following values are considered applicable for medium-dense to dense granular formations:

$K = 0.7$ for axial compressive loads

Soil Type	ϕ	ϕ'	$f_{\max.}$ tsf	N_q	$q_{\max.}$ tsf
Clean sand	35°	30°	1.0	40	100
Silty sand	30°	25°	0.85	20	50
Sandy silt	25°	20°	0.7	12	30
Silt	20°	15°	0.5	8	20

where:

ϕ = angle of internal friction of soil
 $f_{\max.}$ = limiting skin friction
 $q_{\max.}$ = limiting end bearing

For piles in loose sand and silt and for jetted or drilled in piles the maximum values will be less than listed above and shall be reduced by some reliable method based on the amount of soil disturbance from installation.

d. **Skin Friction and Point Resistance of Grouted Piles in Rock.** The unit skin friction of grouted piles in jetted or drilled holes in rock should not exceed the triaxial shear strength of the rock or grout, but in general shall be much less than this value based on the amount of reduced shear strength from installation. For example the strength of dry compacted shale may be greatly reduced when exposed to water from jetting or drilling. The sidewall of the hole may develop a layer of slacked mud or clay which will never regain the strength of the rock.

The end bearing capacity of the rock shall be determined from the triaxial shear strength of the rock

and an appropriate bearing capacity factor based on sound engineering practice for the rock materials but shall not exceed 100 tons per square foot.

e. **Allowable Bearing Capacity.** The ultimate pile bearing capacity shall be divided by an adequate factor of safety to determine the allowable pile bearing capacity. The factor of safety shall not be less than the following values:

Loading Condition	Safety Factor
1. Design environmental condition with appropriate drilling loads	1.5
2. Operating environmental conditions during drilling operations	2.0
3. Design environmental conditions with appropriate producing loads	1.5
4. Operating environmental conditions during producing operations	2.0
5. Design environmental conditions with minimum loads	1.5

2.27 **Pile Capacity for Axial Pullout Loads.** The ultimate pile pullout capacity may be equal to or less than but shall not exceed Q_t , the total skin friction resistance. The effective weight of the pile and hydrostatic uplift shall be considered in the analysis to determine the ultimate pullout capacity. For clay, f shall be the same as stated in Par. 2.26b. For sand and silt, f shall be computed according to Par. 2.26c. All values are applicable except $K = 0.5$ shall be used.

For rock, f shall be the same as stated in Par. 2.26d. The allowable pullout capacity shall be determined by applying the factors of safety in Par. 2.26e to the ultimate pullout capacity.

2.28 Soil Reaction for Laterally-Loaded Piles

a. **General.** The pile foundation shall be adequate to develop a safe reaction for cyclic or static lateral design loads. To resolve this, the lateral load-deflection relationships of the soil-pile interaction must be determined. This parameter is variable for all soils. The following general criteria are recommended in the absence of more definitive criteria.

b. **Lateral Bearing Capacity for Soft Clay.** For static lateral loads the ultimate lateral bearing capacity of soft clay, q , has been found to vary between 8c and 12c depending on mode of failure. Although this is true at deeper depths, at shallower depths it is considerably reduced due to minimum overburden pressure. Moreover, cyclic loads cause deterioration of load resisting ability, hence the reduction should be taken into account. Unless more definitive data are available the following is recommended.

q increases from 0 to 9c as X increases from 0 to 3D, and $q = 9c$ for $X > 3D$(12)

where:

q = ultimate lateral bearing capacity
 c = undrained shear strength of clay on undisturbed soil samples

D = pile diameter

X = distance from soil surface

c. **Soil Modulus for Soft Clay.** Lateral load-deformation (p - y) relationships for piles in soft clay are generally non-linear. These p - y relations should be derived from laboratory stress-strain data. Pile deflection (y) may be related to laboratory strain by:

$y = AD\varepsilon$(13)

where:

p = lateral pile resistance, pounds per inch of diameter per inch of pile length

y = pile lateral deflection, in.

A = coefficient varying from 1.5 to 3.0

D = pile diameter, in.

ε = laboratory strain from undrained compression tests of undisturbed samples.

The lateral pile resistance, p , at a given deflection, y , and a given depth, X , may then be determined by scaling the laboratory shear stress-strain relation for the soil at that depth in accordance with the definition of q in Par. b above. Hence, the ultimate pile resistance at a given depth will be equal to q for the depth and will occur at a pile deflection corresponding to the laboratory strain where the maximum shear stress is reached.

d. **Lateral Bearing Capacity for Stiff Clay.** For static lateral loads the ultimate bearing capacity q of stiff clay ($c > 1$ Tsf) as for soft clay would vary between 8c and 12c. Due to rapid deterioration under cyclic loadings the ultimate resistance, q , will be reduced to something considerably less and should be so considered in cyclic design.

e. **Soil Modulus for Stiff Clay.** While stiff clays also have non-linear stress-strain relationships, they are generally more brittle than soft clays. In developing stress-strain curves and subsequent p - y curves for cyclic loads, good judgment should reflect the rapid deterioration of load capacity at large deflections for stiff clays.

f. **Lateral Bearing Capacity for Sand.** The allowable lateral bearing capacity for sand may be resolved by the equation:

$$q = 3 p_o K_p = 3 p_o \frac{(1 + \sin \phi)}{(1 - \sin \phi)} \dots \dots \dots (14)$$

where:

q = allowable lateral bearing pressure

p_o = effective overburden pressure

K_p = Rankine passive earth pressure coefficient

ϕ = angle of internal friction of sand.

h. **Soil Modulus for Sand.** The lateral load-deflection relationships for piles driven through sand may be resolved by the equation

$$\frac{p}{y} = \frac{A p_o}{1.35 D} \dots \dots \dots (15)$$

where:

p = lateral bearing pressure

y = lateral pile deflection

p_o = effective overburden pressure

D = pile diameter

A = coefficient of sand density

The range of A varies from 200 for loose sand to 500 for dense sand.

2.29 Mat and Spread Footings

a. **Bearing Capacity of Clay.** The ultimate vertical bearing capacity, q , of clay shall be resolved by the equation:

$$q = 7.4c + p_o \dots \dots \dots (16)$$

where:

c = undrained shear strength of clay

p_o = effective overburden pressure

b. **Bearing Capacity of Sand and Silt.** The ultimate vertical bearing capacity, q , of sand and silt shall be resolved by the equation:

$$q = p_o N_q + 0.3 \gamma D N_\gamma \dots \dots \dots (17)$$

where:

p_o = effective overburden pressure

N_q = bearing capacity factor as stated in Par. 2.26c

γ = effective unit weight of soil

D = diameter or width of footing

N_γ = bearing capacity factor

for: $\phi = 15^\circ \quad 20^\circ \quad 25^\circ \quad 30^\circ \quad 35^\circ$

$N_\gamma = 2 \quad 4 \quad 10 \quad 20 \quad 40$

c. **Allowable Bearing Capacity.** The allowable bearing capacity shall not exceed one-half the ultimate bearing capacity.

2.30 Group Action. Due consideration should be given to the effects of close spacing on the load and deflection characteristics of pile groups. The allowable load for a group, both axial and lateral, can be much less than the sum of the apparent individual pile allowable loads.

MATERIAL

2.31 Structural Steel

a. Unless otherwise specified or approved by the designer, steel for hot-rolled structural shapes and plates shall conform to one of the following specifications:

1. Structural steel for ships ASTM A 131 (Yield Point $F_y = 32$ ksi).
2. Structural steel ASTM A 36 ($F_y = 36$).
3. High strength low alloy Manganese-Vanadium structural steel ASTM A 441; ($F_y = 50$ ksi for $\frac{3}{4}$ in. and under, 46 ksi for over $\frac{3}{4}$ in. to 1 $\frac{1}{2}$ in. inclusive, and 42 ksi for over 1 $\frac{1}{2}$ in. to 4 in. inclusive).
4. High strength low alloy Columbian-Vanadium steels of structural quality ASTM A 572, Grade 42 ($F_y = 42$) and Grade 50 ($F_y = 50$).

Certified mill test reports or certified reports of tests made by the fabricator or a testing laboratory in accordance with ASTM A 6 shall constitute evidence of conformity with one of the above.

b. Unidentified steel shall not be used.

c. Consideration should be given for the selection of steels with notch toughness characteristics suitable for the environmental temperature.

2.32 Structural Steel Pipe

a. Unless otherwise specified or approved by the designer, all seamless or electric weld pipe shall meet one or more of the following industry standards (latest edition):

1. Line pipe API Std 5L Grade B ($F_y = 35$).
2. Welded and seamless steel pipe ASTM A 53 Grade B ($F_y = 35$).
3. Seamless carbon steel pipe for high temperature service ASTM A 106 Grade B ($F_y = 35$).
4. Electric Fusion (arc) welded steel pipe ASTM A 139 Grade B ($F_y = 35$).
5. Electric resistance welded steel pipe ASTM A 135 Grade B ($F_y = 35$).
6. Metal arc welded steel pipe for high pressure transmission service — ASTM A 381 Grade Y 35 ($F_y = 35$).

b. Pipe may be fabricated from grades of structural plate listed in Par. 2.31a as specified in ASTM A 139; ASTM A 155; ASTM A 252 or ASTM A 381, except that hydrostatic testing may be omitted.

c. All pipe shall be prime quality unless the use of limited service, structural grade, or reject pipe is specifically approved by the designer.

d. Consideration should be given for the selection of steels with notch toughness characteristics suitable for the environmental temperature.

2.33 Steel for Tubular Joints. Tubular joints are generally subject to local yield stress and plastic strains at the design load; during their service life both impact and plastic fatigue loading are to be expected, making additional demands on the steel.

a. **Joints Under Water.** For underwater portions of redundant template-type platforms, joint steel should, with 90% reliability, meet the Charpy V-notch impact properties of 30% shear for as-rolled steel and 50% shear for heat treated steel at the lowest expected water temperature. This provision need not apply to the body of the braces (between joints).

b. **Joints Above Water.** For exposed above water connections subject to impact from boats at lower temperatures, or for critical connections at any location in which it is desired to prevent all brittle fractures (for example, in the presence of large fatigue cracks), the use of tougher steels is recommended. This usually will require thick sections to be heat treated, and special attention to welding procedures.

MAINTENANCE AND CORROSION

2.34 Zone Definition. The areas of a platform are divided into three sections in regard to corrosion protection. These areas are:

a. **Splash Zone.** That area extending 6 feet above high tide to 4 feet below low tide. These distances shall be adjusted as necessary to accommodate larger or smaller variations in tides.

b. **Atmospheric Zone.** That area extending above the splash zone.

c. **Submerged Zone.** That area lying beneath the splash zone.

2.35 Protection in Splash Zone. The splash zone area shall be protected by one of the following methods:

a. Extra steel in excess of that needed for strength.

b. Noncorrosive metallic wrap.

c. Coatings.

2.36 Protection in Atmospheric Zone. All steel surfaces in the atmospheric zone should be protected against corrosion. Proper surface preparation and application of materials selected will prove most economical. Various paint systems and galvanizing have proved satisfactory. Application procedures should follow the manufacturer's recommendations closely.

2.37 Protection in Submerged Zone. One of the following methods shall be used to protect the structure in the submerged zone:

a. Cathodic protection with sacrificial anodes.

b. Cathodic protection with impressed current.

DRAWINGS

2.38 Design Drawings. The design drawings should show a complete design with sizes, sections and relative locations of the various members.

2.39 Shop Drawings. Shop drawings need be prepared only when necessary for clarity of detail for a fabrication.

SECTION 3

SAFETY CONSIDERATIONS

3.1 Introduction. The safety of life and property depends on the ability of the structure to survive the environmental conditions for which it was designed. In addition to this overall concept, certain detail elements are important to guard against injuries to personnel during the construction and/or operation of fixed offshore platforms, and to minimize the risks of damage by collision by ships and other powered vessels. These are cited below. All government safety regulations must also be adhered to.

3.2 Aids to Navigation. In general, all artificial islands and structures erected offshore, whether permanent or temporary, must have obstruction lights and fog signals installed thereon. Part 67 of CG 320, entitled *Private Aids to Navigation, Outer Continental Shelf and Waters Under the Jurisdiction of the United States*, prescribes in detail the require-

ments of lights and foghorns. An expansion of *Aids to Navigation Regulations*, is contained in CG 208 pamphlet which are copied from Subchapter C (Aids to Navigation) of Chapter I of Title 33CFR.

3.3 Coast Guard Regulations. Due consideration shall be given to meeting all safety requirements of the U. S. Coast Guard. The *Rules and Regulations for Artificial Islands and Fixed Structures on the Outer Continental Shelf*, establish certain requirements with respect to safety equipment and the promotion of safety of life and property on structures. These rules are enforced by the U. S. Coast Guard and are a part of the requirements of Section 4 (e) of the *Outer Continental Shelf Lands Act, Title 33, CFR (Code of Federal Regulations)* Parts 140 to 146 inclusive; also known as CG 320 published by U. S. Coast Guard.

SECTION 4

WELDING

GENERAL

4.1 Welding shall be done in accordance with the latest edition of *Specification for Welded Highway and Railway Bridges*, AWS D2.0 and, where applicable, other AWS Rulings, Supplements and Addendas to AWS D2.0.

4.2 Welding Procedures. Limitations imposed by the essential variables of the procedure qualification shall be adhered to in production welding.

4.3 Welders. Welders shall be qualified for the type of work assigned and be issued certificates of qualification stating such limitations as process (F-number) and position.

QUALIFICATION PROCEDURES

4.4 General. Welding procedures, welders and welding operators shall be qualified in accordance with American Welding Society's D2.0 and further qualified herein.

a. Impact Requirements. If ASTM specifications do not require minimum Charpy V-notch impact properties for the electrodes and fluxes that are to be used for procedure qualification, then Charpy V-notch test specimens shall be removed and tested according to ASTM A 370 and E 23. The as-deposited weld metal is required to have a minimum impact strength of 20 ft.-lbs. at 0 F for welds in tubular joints or welds joining high strength steel.

b. Radiographic Inspection. In addition to the tests required above, procedure qualification for gas metal-arc welding requires radiographic inspection of

complete-penetration groove welds prior to the removal of the test specimens. The radiographs shall conform to the requirements of AWS D2.0.

4.5 Performance of Procedure Tests. Qualification tests shall be performed by a competent testing laboratory.

4.6 Prior Qualifications. New qualifications may be waived if prior qualifications are deemed suitable.

WELDING AND INSPECTION

4.7 General. All welding shall conform to sizes of welds and notes on drawings; otherwise, welding and inspection shall conform to the American Welding Society's Specifications listed under Par. 4.1 above and further qualified herein.

4.8 Penetration of Welds. All welds should be complete-penetration welds unless otherwise specified.

4.9 Groove Welds. Groove welds made from one side only, without backing, will be permitted where two or more tubular members intersect, preventing access to the root side of the weld.

4.10 Seal Welds. Unless otherwise specified, seal welds shall be continuous $\frac{1}{8}$ in. fillet welds to seal faying surfaces against corrosion.

4.11 Inspection and Tests. Nondestructive inspection and tests, such as radiographs, ultrasonic, magnetic particle and dye penetrant, may be employed to the degree and extent deemed necessary to achieve compliance with the specifications. Inspection should be scheduled so as not to delay the progress of the job.

SECTION 5

FABRICATION

ASSEMBLY

5.1 General. All fabrication, other than welding, shall be in accordance with the *Specification for the Design, Fabrication and Erection of Structural Steel for Buildings and Bridges*, AISC, latest revision, unless otherwise specified herein.

5.2 Location of Splices

a. Pipe. Splicing Pipe — Sections of pipe of the

same diameter and wall thickness may be spliced. Splices shall not be located closer together than three feet or one diameter of the pipe, whichever is smaller. There shall be no more than two splices in any ten-foot interval of pipe.

b. Beams. Splicing beams — Sections of beams with the same cross-sections may be spliced. The use of the beam shall determine the location and fre-

quency of splicing. In cantilever beams there shall be no splice located closer to the point of support than one-half the cantilevered length. For beams employed in any span between supports, there shall be no splice in the middle one-fourth of any span nor in the eighth of the span nearest any support nor over any support. Splices shall not be located closer together than twice the depth of the beam, or three feet whichever is smaller. Other splice locations may be used subject to approval of the designer.

5.3 Final Fabrication Tolerances

a. **General.** The location of each member results from the design of the entire structure. It shall be necessary to locate accurately the various components of the structure to the final fabrication tolerances hereafter given. Other tolerances not stated herein shall be in accordance with *Specifications For The Design, Fabrication and Erection of Structural Steel For Buildings and Bridges*, AISC, latest revision.

b. **Jacket and Deck Section Column.** In any plane critical to field assembly the horizontal distance from the center line of any column to the center line of the column adjacent in any direction shall be within a tolerance of $\pm \frac{1}{4}$ in. of the net drawing dimension. In other planes this tolerance may apply to working points on the outside diameter of the columns.

The angle between a taut line stretched from a corner column to the next corner column on the one side of the jacket and a taut line from the same corner column to the next corner column on the adjacent side of the jacket shall be within one minute of the angle indicated on the drawing. Diagonal distances between diametrically opposite corner columns shall be checked. If such diagonal distances vary more than $\frac{1}{4}$ in., corrective measures shall be taken. Every practical effort shall be exerted to effect accuracy in column alignment horizontally at all planes.

Alignment of jacket columns shall be maintained within $\pm \frac{1}{4}$ in. The jacket fabrication shall proceed on a flat and level surface. Frequent checks of blocking shall be performed. When any column settles out of level, the settled column shall be shimmed back into a level plane with other columns. The tops of all jacket columns shall relate to the drawing elevation within a tolerance of $\pm \frac{1}{4}$ in.

c. **Jacket and Deck Section Bracing.** All braces in a horizontal plane shall be held vertically within $\pm \frac{1}{2}$ in. tolerance of drawing dimension.

All other bracing where the end points are dimensioned shall be erected so that such points fall within $\pm \frac{1}{2}$ in. from planned dimension.

d. **Deck Beams.** The center-lines of deck beams at their ends shall fall within $\pm \frac{1}{2}$ in. of drawing location. At no point along the beam center-line shall there be more than $\pm \frac{3}{4}$ in. out of line horizontally or $\pm \frac{1}{2}$ in. vertically.

Deck beams shall be erected with the top flanges level throughout their full lengths. Disparity in beam depth and flange out of level due to allowable mill tolerances in depth will be acceptable. Deck beams shall be erected with the webs plumb. Distortion of deck beams from welding shall be corrected or otherwise compensated so that tolerances established in this Section shall be met.

e. **Cap Beams.** The center-lines of cap beams at their ends shall fall within $\pm \frac{1}{2}$ in. of drawing dimension. At no point along the center-line shall the cap beam be more than $\frac{3}{4}$ in. out of line horizontally or $\frac{1}{4}$ in. vertically.

Cap beams shall be erected with the top flanges

level. Disparity in beam depth due to mill tolerances in depth shall be compensated by shimming between the bottom columns.

Cap beams shall be erected with the webs plumb. Distortion of cap beams from welding shall be corrected or otherwise compensated so that tolerances established in this Section shall be met.

f. **Grating.** Joints in grating shall occur only at points of support.

g. **Fencing and Handrails.** Fabrication shall be performed to such a degree of accuracy that, when erected, the top rail will be straight and level to the eye.

h. **Landings and Stairways.** Landing elevations and landing and stairway locations horizontally shall be within 3 in. of drawing dimensions.

i. **Piles.** The outside circumference shall be within $\pm 1\%$ of the nominal circumference and in no case more than $\frac{3}{4}$ in. more or less than the nominal circumference.

The out-of-roundness, i.e., the difference between the major and minor outside diameters, shall not exceed 1% of the nominal diameter, except that $\frac{1}{4}$ in. shall be maximum.

The minimum length of a segment of pipe used in fabricating piles shall be five feet. The longitudinal seams of two adjacent pile segments shall be spaced 90 Deg apart as a minimum.

The maximum allowable deviation from straightness in any 10-foot increment of length shall be $\frac{1}{4}$ in. The maximum allowable deviation in any 40 foot increment shall be $\frac{3}{4}$ in. For lengths over 40 feet, the maximum allowable deviation shall be $\frac{1}{2}$ in. Corrective action shall be taken to prevent additional accumulation of deviation. The method for checking straightness shall be by taut wire along the length of pipe repeated at a minimum of three radius points.

The root face on the beveled ends of the finished pipe shall not be out of square more than $\frac{1}{16}$ in. per foot of diameter except that the maximum allowable shall not be more than $\frac{1}{4}$ in.

Piles shall be fabricated to a tolerance of ± 1 ft from the length shown on the drawings or as otherwise specified.

j. **Splash Zone Protection.** Splash zone protective measures shall be installed to protect as a minimum those areas indicated on the drawing.

COATINGS

5.4 **General.** Unless specified otherwise by the designer, the application of coatings should conform with the following:

5.5 Surface Preparation

a. **General.** Surface preparation shall be in accordance with the coating manufacturer's recommendations, as per the applicable SSPC Standards.

b. **Sandblasting.** Sandblasting shall not be done in areas close to painting operations and wet coated surfaces to prevent dust and sand contamination.

c. **Cleaning of Metal.** All welded areas and appurtenances shall be given special attention for removal of welding flux in crevices. Welding splatter, slivers, laminations, and underlying mill scale not removed during fabrication and exposed before and during sandblasting operations shall be removed by best mechanical means and edges smoothed or rendered flush.

5.6 Coating Materials

a. All coating materials or paints for a given area shall be the product of one manufacturer.

b. All coating material or paints shall be furnished in unopened containers and shall be properly labeled as to their contents.

c. If coating material requires the addition of a catalyst, the pot life under application conditions shall be clearly stated on the label. This pot life shall not be exceeded.

5.7 Coating Application

a. The surface must be clean, free from dust and

sand, and be dry before priming or application of any coat of paint.

b. Paint application shall be done according to the paint manufacturer's recommendations.

c. All coating film thicknesses must be within the tolerances specified by the coating manufacturer. These film thicknesses are to be checked with calibrated film thickness gages.

d. Prior to application of any coat of material, all damage to previous coats shall be properly repaired.

SECTION 6 INSTALLATION

GENERAL

6.1 The installation of a platform consists of transporting the various components of the platform to the installation site, positioning the platform on the site and assembling the various components into a stable structure in accordance with the design. The installation of a platform must be accomplished in such a manner that the platform will fulfill the intended design purpose.

TRANSPORTATION

6.2 The movement of the platform components from a fabrication yard to an installation site presents a complex task which requires detailed advanced planning. Basic considerations vary with reference to the type of platform to be transported. Included herein are those items which, at a minimum, should be considered.

6.3 Template-type Platforms

a. Consideration should be given to transporting the following items of a template-type platform: a jacket (welded tubular space frame), piling, superstructure and other miscellaneous items.

b. An adequate number of seaworthy cargo barges must be provided. If the jacket portion of the platform is to be launched from a barge without the use of a derrick barge, the launch barge must be capable of this operation.

c. The various platform parts must be loaded on the barges in such a manner to insure a balanced and stable condition. Ballasting of the barge as required should be performed.

d. Adequate ties for all platform components to prevent shifting while in transit should be designed and installed. These ties should be adequate for the severest weather that may be encountered during the voyage.

e. The proper number of seagoing tugs with sufficient power and size to operate safely in any sea environment that may develop for each particular route or ocean traveled should be provided.

f. Due consideration shall be given to the forces applied to the various platform components as they are lifted on and off the barges or as they are rolled on and launched off the barges.

g. The buoyancy of any platform component to be launched shall be determined to insure the unit will float. The flooding system required, if any, for righting or placement, the buoyancy components and any necessary lifting connections shall be designed as necessary.

6.4 Tower-type Platform

a. The tower-type platform consists of a tower substructure which is floated to the installation site and placed in position by selective flooding. This substructure is also called a jacket. It has multiple piling and a superstructure. The movement considerations should include those specified for the template-type platform in addition to others listed herein.

b. The water tightness of each buoyant and ballast compartment shall be determined as well as the buoyancy of the overall component to be towed.

c. Consideration shall be given to the location and accessibility of all controls for selective flooding and righting as well as the protection of the controls from the environments.

d. Because of the problems which may be encountered, it is recommended that model tests or detailed calculations be performed for the prototype to determine towing and stability characteristics during towing and righting.

6.5 Caisson-type Platform. The caisson-type platform, depending on the size, should include all applicable considerations specified above for both the template and tower-type platforms.

REMOVAL OF JACKET FROM CARGO BARGE

6.6 This section primarily pertains to the template-type platform jacket which has been transported to the installation site by a barge and specifically pertains to those actions taken to remove the jacket from the barge to the water. Generally speaking, removal of the jacket from the barge can be accomplished by either lifting with a derrick barge or launching.

6.7 Lifting the Jacket Off the Barge With a Derrick Barge. The rigging should be properly designed to lift safely a jacket off a barge and lower it into the water. Usually the slings are attached above the center of gravity of the jacket being lifted to avoid possible damage to the jacket and/or barge during the lifting process.

6.8 Launching the Jacket Off the Barge. For those jackets which are to be launched it is necessary to design a launching system. Items listed herein should be considered.

a. The launch barge should be equipped with launch ways, rocker arms, controlled ballast and de-watering system, and power unit (hydraulic ram, winch, etc.) to assist the jacket to slide down the ways.

b. The jacket to be launched must be designed and fabricated to withstand the stresses caused by the launch. This can be done by either strengthening

those members that might be overstressed by the launching operation or designing into the jacket a special truss, commonly referred to as a launch truss. A combination of the above two methods may be required.

c. A jacket which is to be launched must be water tight and buoyant to allow lifting slings to be attached to the derrick barge. The structure launched must float in a known position so that slings previously attached are exposed and accessible.

d. The derrick barge must be of sufficient size to change the position of the launched jacket from its floating position to its erected position, or to hold the launched jacket at the site until it can be righted by a controlled flooding system.

ERECTION

6.9 This section encompasses generally the placement and assembling of the platform so that the finished structure is ready for inspection prior to the initiation of its intended purpose.

a. All placement and assembling of the platform should be in accordance with instructions which indicate the installation procedure and pile make-up. All piles should be marked in a manner to facilitate installing the pile sections together in proper sequence.

b. All necessary measures should be employed to protect the construction, to include observance of all safety regulations of the state and federal bodies having jurisdiction over the waters and area around the installation site. This should include, as required, the provision and maintenance of all necessary safety and navigational aids and other measures in observance of appropriate state and federal regulations.

6.10 Anchorage. Appropriate anchoring of the derrick and supply barges is of vital consideration during the erection phase. Basic principles to be considered and provided for are outlined herein.

a. The length of anchor lines required which, depending on the water depth, should be determined.

b. Anchor sizes and shapes should be selected so that they will bite and hold in the ocean bottom at the site. This holding action should be sufficient to resist the strongest tides, currents and winds that may reasonably be expected to occur at the site during the erection phase.

c. Where it appears that the desired anchorage may not be totally possible, orientation of construction equipment should be such that, if the anchors slip, the derrick and supply barges will move away from the platform.

6.11 Positioning. The term, "positioning," generally refers to the placement of the jacket on the installation site in preparation for the piling to be installed. This may require up-ending of those plat-

form components which have been towed to the site or launched from a barge at the site. Generally, the up-ending process is accomplished by a combination of a derrick barge and controlled or selective flooding system. This up-ending phase requires advanced planning to pre-determine the simultaneous lifting and controlled flooding steps necessary to set the structure on site. Closure devices, lifting connections, etc., have to be provided where necessary. The flooding system should be designed to withstand the water pressures which will be encountered during the positioning process.

Where the jacket is to be installed over an existing well, the wellhead should be properly protected from damage through accidental contact with the substructure. Advance planning and preparation should be in such detail as to minimize hazards to the well and structure.

6.12 Pile Installation. Proper installation of piling is vital to the life and permanence of the platform. When adequate soil information has been obtained at the site, and if information is available from the driving of a conductor pipe, this data should be at the job site.

a. Leveling Jacket. The jacket should be leveled to within a reasonable tolerance before any piles are driven. Once this is accomplished, piling should be driven through selected legs of the jacket after which the jacket should again be leveled to a final tolerance.

b. Closure Devices. Closure devices, if present, will be removed. Care should be exercised to insure that the closure device is out of the way of the pile to prevent interference with the driving of the pile.

c. Obtaining Desired Pile Penetration. Proper pile installation requires that all piles be driven to design penetration. In the event a pile reaches refusal before the minimum penetration has been obtained, jetting or drilling may be necessary to achieve a revised penetration. Before starting to drill or jet, the design engineer should be notified. Any required remedial measures, such as drilling or jetting, should be planned with and approved by the design engineer.

6.13 Superstructure Installation. After the piling has been driven and cut off to grade, the superstructure should then be set with proper care being exercised to insure proper alignment and elevation. The deck elevation shall not vary more than ± 3 in. from the design elevation shown in the drawing. The finished elevation of the deck shall be within $\frac{1}{2}$ in. of being level.

Once the superstructure is installed, all stairways, handrails, and other similar appurtenances should be installed as specified.

SECTION 7 INSPECTION

7.1 Inspections should be performed to insure adherence to the plans and specifications which contain the detailed instructions necessary to obtain the desired quality and service in the finished product. It is necessary to provide for inspection and tests during both the fabrication and erection phases to insure that specified requirements are being met.

7.2 Personnel. Authorized personnel shall have access to manufacturing and erection areas at all times during the progress of the work to insure that desired quality of workmanship is obtained during fabrication and erection.

7.3 Methods of Inspection. The use of any or all recognized testing methods deemed necessary to as-

sist in adequate determination of the soundness of material or welds may be employed. Inspection may be used to insure the adequacy of workmanship during fabrication and installation. The plans and specifications shall clearly delineate which materials and fabricated items are to be inspected and the methods to be used in such inspections.

7.4 Radiographic Inspection. Radiograph film interpretation shall be in accordance with AWS D2.0.

7.5 Magnetic Particle Inspection. The procedure for magnetic particle inspection shall conform to the requirements of ASTM Specification E109-63, *Dry Powder Magnetic Particle Inspection*.

7.6 Ultrasonic Inspection. Ultrasonic inspection may be performed in accordance with applicable standards.