

Specification for Drilling and Well Servicing Structures

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Contents

	Page
1 Scope.....	1
2 Normative References	1
3 Terms and Definitions	2
4 Product Specification Levels.....	5
5 Marking and Information	5
5.1 Nameplate	5
5.2 Derrick and Mast Nameplate Information	5
5.3 Service Rig Mast Nameplate Information	6
5.4 Substructure Nameplate Information	7
5.5 Crown Block Assembly Nameplate Information (Required Only for Crown Block Assemblies for Use with Derricks)	8
6 Structural Safety Level.....	8
7 Design Loading	9
8 Design Specification	11
8.1 Allowable Strength	11
8.2 Design for Stability	13
8.3 Operating Loads	14
8.4 Wind Loads	14
8.5 Dynamic Loads	23
8.6 Earthquake Loads.....	24
8.7 Ice Loads	24
8.8 Erection Loads	24
8.9 Transportation Loads	24
8.10 Overturning and Sliding	25
8.11 Design Verification	26
8.12 Design Validation	26
9 Materials	26
9.1 General	26
9.2 Written Specifications	26
9.3 Mechanical Properties	27
9.4 Material Qualification	27
9.5 Material Manufacture	27
9.6 Bolts	27
9.7 Wire Rope	27
10 Welding Requirements.....	27
10.1 General	27
10.2 Welding Qualifications	27
10.3 Written Documentation	28
10.4 Control of Consumables	28
10.5 Weld Properties	28
10.6 Postweld Heat Treatment	28
10.7 Quality Control Requirements.....	28

Contents

	Page
10.8 Specific Requirement—Repair Welds.....	28
11 Quality Control	29
11.1 General	29
11.2 Quality Control Personnel Qualifications	29
11.3 Measuring and Test Equipment	29
11.4 Nondestructive Examination	29
11.5 Dimensional Verification	30
11.6 Workmanship and Finishing.....	31
11.7 Purchaser's Inspection and Rejection	31
11.8 Testing	31
11.9 Traceability.....	32
11.10 Processes Requiring Validation	32
12 Documentation.....	33
12.1 General	33
12.2 Documentation to Be Kept by the Manufacturer	33
12.3 Documentation to Be Delivered with Equipment	34
Annex A (normative) Supplementary Requirements.....	35
Annex B (informative) Commentary	37
Annex C: The information in this annex has been intentionally removed.....	49
Annex D (informative) Purchasing Guidelines.....	50
Bibliography.....	55

Figures

1 Member Angle of Inclination	19
2a Shape Coefficients.....	21
2b Shape Coefficients (Continued).....	22
3 Member Projected Area	23
B.1 Projected Area Approach	43
B.2 Projected Pressure Approach	43
B.3 Velocity Component Approach.....	44

Tables

1 Structural Safety Levels for Drilling Structures	9
2 Design Loadings for Drilling Structures	10
3 Design Loadings for Service Rig Masts.....	10
4 Onshore Structural Safety Level Multiplier, α_{onshore}	15
5 Offshore Structural Safety Level Multiplier, α_{offshore}	16

Contents

	Page
6 Minimum Design Wind Speed m/s (knots), V_{des}	16
7 Elevation Factor, β Location: All	17
8 Gust Effect Factor	20
A.1 Adjustment Factors for Subsize Impact Specimens	35
B.1 Wind Force Components Using Three Approaches.....	44

Specification for Drilling and Well Servicing Structures

1 Scope

This specification states requirements and gives recommendations for suitable steel structures for drilling and well servicing operations in the petroleum industry, provides a uniform method of rating the structures, and provides two product specification levels (PSLs).

This specification is applicable to all new steel derricks, masts (including masts with guy lines and service rig masts), substructures, and crown block assemblies with a date of manufacture after the effective date of this specification.

[Annex A](#) provides standard supplementary requirements (SRs) that apply only if specified by the purchaser. [Annex B](#) is an informative annex to assist in an understanding/application of this API specification. [Annex C](#) is an informative annex regarding the API Monogram Program and the API Monogram marking requirements. [Annex D](#) is an informative annex providing guidelines to assist the purchaser with purchasing equipment manufactured to the requirements in this API document.

2 Normative References

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any addenda) applies.

API Bulletin 2INT-MET, *Interim Guidance on Hurricane Conditions in the Gulf of Mexico*

API Recommended Practice 2A-WSD, *Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms—Working Stress Design*

API Recommended Practice 4G, *Recommended Practice for Use and Procedures for Inspection, Maintenance, and Repair of Drilling and Well Servicing Structures*

API Recommended Practice 9B, *Recommended Practice on Application, Care and Use of Wire Rope for Oilfield Service*

API Specification 8C, *Specification for Drilling and Production Hoisting Equipment (PSL 1 and PSL 2)*

API Specification 9A, *Specification for Wire Rope*

ANSI/AISC 360-16, *Specification for Structural Steel Buildings*

ASCE/SEI 7-05,¹ *Minimum Design Loads for Buildings and Other Structures*

ASTM A370,² *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

ASTM A578/A578M, *Standard Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications*

AWS D1.1/D1.1M,³ *Structural Welding Code —Steel*

¹ American Society of Civil Engineers, 1801 Alexander Bell Drive Reston, Virginia 20191, www.asce.org.

² ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, Pennsylvania 19428-2959, www.astm.org.

³ American Welding Society, Incorporated, 8669 NW 36 Street, # 130, Miami, Florida 33166-6672, www.aws.org.

ISO 19901-1, *Part 1, Metocean Design and Operating Considerations*

ISO 9712,⁴ *Non-destructive Testing—Qualification and Certification of Personnel*

3 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

3.1

appurtenances

All components attached to but not part of the *bare drilling structure*.

3.2

bare drilling structure

The structural members of the drilling structure including crown, water table, and gin pole as applicable.

3.3

clear height

Minimum vertical distance. For derrick and mast without guy lines, this means from the top of the working floor to the bottom of the crown block support beams. For mast with guy lines, this means from the top of the working floor to the bottom of the crown block support beams. For service rigs with guy lines, this means from the ground to the bottom of the crown block support beams.

3.4

critical component

Component that is necessary to maintain stability of a structure and that resides within the primary load paths of the structure when the structure is loaded under the design loadings of [Section 7](#).

3.5

critical weld

Weld that joins critical components.

3.6

crown block assembly

The set of components including sheave or block assemblies installed at the top of a derrick or mast to support the hook load.

3.7

date of manufacture

Date chosen by the manufacturer occurring between the initiation of manufacture and the delivery to the purchaser.

3.8

derrick

Structural tower, of square or rectangular cross section, having members that are latticed or trussed on all four sides.

NOTE It may or may not be guyed.

3.9

design load

Force or combination of forces that a structure is designed to withstand without exceeding the allowable member strength in any member.

⁴ International Organization for Standardization, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, www.iso.org.

3.10**design pressure**

Maximum allowable pressure that the cylinder is designed to withstand.

3.11**design reference wind velocity**

V_{ref}

The wind velocity of a 3-second gust at a 10 m (33 ft) reference elevation, in knots, for the appropriate return period at the intended drilling location.

3.12**design validation**

The process of proving a design to demonstrate conformity of the product to design requirements.

3.13**design verification**

The process of examining the result of design and development output to determine conformity with specified requirements.

3.14**dynamic loading**

Loading imposed upon a structure as a result of motion.

3.15**erection load**

Load produced in the mast and its supporting structure during its raising and lowering, or in the substructure during its raising and lowering.

3.16**guide tracks and dollies**

Equipment used to hold the traveling equipment in correct position relative to the derrick during various operations.

NOTE A retractable dolly is used move the traveling equipment horizontally between the drilling position and the retracted position.

3.17**guy line**

Wire rope with one end attached to the mast assembly and the other end attached to a suitable anchor to provide structural and/or lateral support for a mast under design loading conditions.

3.18**guying pattern**

Plan view showing the manufacturer's recommended locations for guy lines and their distance out to the anchors with respect to the centerline of the well.

3.19**heave**

Distance of movement from above or below horizontal.

3.20**impact loading**

Loading resulting from near-instantaneous changes of forces.

3.21**mast**

Structural latticed tower of rectangular cross section with an open face.

3.22**mast setup distance**

Distance from the centerline of the well to a designated point on the mast structure defined by a manufacturer to assist in the setup of the rig.

3.23**maximum rated design wind velocity** V_{des}

The wind velocity after adjustment for SSL by the onshore or offshore factor of a 3-second gust at a 10 m (33 ft) reference elevation, in knots, used to calculate the force that the drilling structure is designed to resist.

3.24**maximum rated static hook load**

Load composed of the weight of the traveling equipment and a static load applied to the traveling equipment.

NOTE It is the largest load that can be applied to the structure within the guidelines imposed by this standard with a specified number of lines strung to the traveling block and in the absence of pipe setback, sucker rod, or wind loading. A designated location of the deadline anchor and drawworks is assumed.

3.25**operating pressure**

Pressure necessary to generate the required push and/or pull forces as defined by the rig designer.

3.26**nominal wire rope assembly strength**

Nominal strength of the wire rope, multiplied by the efficiency of the end attachment in accordance with API 9B.

3.27**period (of roll, pitch or heave)** τ

Time required for a complete cycle.

3.28**pipe lean**

Angle between the vertical and a typical stand of pipe in the setback.

3.29**product specification level****PSL**

Level of material and process controls placed upon the primary load-carrying components of the covered equipment.

3.30**racking platform**

Platform located at a distance above the working floor for laterally supporting the upper end of racked pipe.

3.31**rated setback**

Maximum weight of tubular goods that can be supported by the substructure in the setback area.

3.32**rated static rotary load**

Maximum weight that can be supported by the rotary-table support beams.

3.33**rod board**

Platform for supporting rods that is located at a distance above the working floor.

3.34**roll
pitch**

Angle of movement to one side from vertical.

3.35**service rig mast**

A mast designed with ratings for operations with or without setback or rods.

NOTE See [Table 3](#).

3.36**structural safety level****SSL**

The classification of a drilling structure application by a purchaser to reflect various degrees of consequence of failure, considering life safety and other issues such as pollution, economic loss, and public concern.

3.37**substructure**

Structure(s) through which the mast load, hook load, rotary load, and/or setback load are transmitted.

3.38**wind environment**

The combination of rig configuration and load combinations to be considered with a given wind loading.

4 Product Specification Levels

This standard establishes requirements for two PSLs for drilling and well servicing structures that define two levels of technical and quality requirements. These requirements reflect practices currently being implemented by a broad spectrum of the manufacturing industry. PSL 1 includes practices currently being implemented by a broad spectrum of the manufacturing industry. PSL 2 includes all the requirements of PSL 1 plus additional requirements.

5 Marking and Information

5.1 Nameplate

Drilling and well servicing structures manufactured in accordance with this standard shall be identified by a nameplate bearing at least the information specified in [5.2](#) through [5.5](#), including the units of measurement where applicable. Markings shall be either raised or stamped. The nameplate shall be securely affixed to the structure in a conspicuous place.

5.2 Derrick and Mast Nameplate Information

NOTE See [5.3](#) for nameplate information for service rig masts.

The following information shall be provided:

- a) manufacturer's name;
- b) manufacturer's address;
- c) date of manufacture, including month and year;
- d) serial number;

- e) clear height, m (ft);
- f) maximum rated static hook load with guy lines, if applicable, for stated number of lines to traveling block, KN (short tons);
- g) maximum rated design wind velocity, V_{des} , at reference elevation of 10 m (33 ft) above mean sea level or ground, in knots, for 3-second gust duration with guy lines, if applicable, *with* rated capacity of pipe racked in racking platform, m/s (knots);
- h) maximum rated design wind velocity, V_{des} , at reference elevation of 10 m (33 ft) above mean sea level or ground, in knots, for 3-second gust duration with guy lines, if applicable, *without* pipe racked in racking platform, m/s (knots);
- i) elevation of base of derrick or mast above mean sea level or ground used in design for wind loading, m (ft);
- j) API 4F, Fifth Edition;
- k) manufacturer's guying pattern, if applicable;
- l) the following text:

CAUTION—Acceleration or impact loading, also setback, rods, and wind loads will reduce the maximum rated static hook load capacity.

- m) manufacturer's load distribution diagram (may be placed in mast instructions);
- n) graph plotting allowable static hook load for wind velocities varying from zero to maximum design rated wind velocity, V_{des} , with full rated setback and with maximum number of lines to traveling block;
- o) mast setup distance for mast with guy lines, m (ft);
- p) PSL 2, if applicable; and
- q) supplementary information as specified in the particular SR, if applicable (see [Annex A](#)).

5.3 Service Rig Mast Nameplate Information

The following information shall be provided:

- a) manufacturer's name;
- b) manufacturer's address;
- c) date of manufacture, including month and year;
- d) serial number;
- e) clear height, m (ft);
- f) maximum rated static hook load with guy lines, if applicable, for stated number of lines to traveling block, KN (short tons);
- g) allowable static hook load with guy lines, if applicable, for stated number of lines to traveling block, KN (short tons) in combination with rated capacity of pipe racked and maximum rated capacity of rods hung in mast, KN (short tons), if applicable;

- h) maximum rated design wind velocity, V_{des} , at reference elevation of 10 m (33 ft) above mean sea level or ground, in knots, for 3-second gust duration with guy lines, if applicable, *with* rated capacity of pipe racked on racking platform, m/s (knots);
- i) maximum rated design wind velocity, V_{des} , at reference elevation of 10 m (33 ft) above mean sea level or ground, in knots, for 3-second gust duration with guy lines, if applicable, *without* pipe racked on racking platform, m/s (knots);
- j) elevation of base of derrick or mast above mean sea level or ground used in design for wind loading, m (ft);
- k) API 4F, Fifth Edition;
- l) manufacturer's guying pattern, if applicable;
- m) the following text:

CAUTION—Acceleration or impact loading, also setback, rods, and wind loads will reduce the maximum rated static hook load capacity.

- n) manufacturer's load distribution diagram (may be placed in mast instructions);
- o) graph plotting allowable static hook load for wind velocities varying from zero to maximum design rated wind velocity, V_{des} , with full rated setback but no rods and with maximum number of lines to traveling block;
- p) mast setup distance for mast with guy lines, m (ft);
- q) PSL 2, if applicable; and
- r) supplementary information as specified in the particular SR, if applicable (see [Annex A](#)).

5.4 Substructure Nameplate Information

The following information shall be provided:

- a) manufacturer's name;
- b) manufacturer's address;
- c) date of manufacture, including month and year;
- d) serial number;
- e) maximum rated static hook load, KN (short tons);
- f) maximum rated static rotary capacity, KN (short tons);
- g) maximum rated pipe setback capacity, KN (short tons);
- h) maximum combined rated static hook and rated setback capacity, KN (short tons);
- i) maximum combined rated static rotary and rated setback capacity, KN (short tons);
- j) for substructures that support a mast or derrick, the following apply:

- maximum rated design wind velocity, V_{des} , at reference elevation of 10 m (33 ft) above mean sea level or ground, in m/s (knots), for 3-second gust duration with guy lines, if applicable, *with* rated capacity of pipe racked;
 - maximum rated design wind velocity, V_{des} , at reference elevation of 10 m (33 ft) above mean sea level or ground, in m/s (knots), for 3-second gust duration with guy lines, if applicable, *without* pipe racked;
 - elevation of base of substructure above mean sea level or ground used in design for wind loading, m (ft);
- k) API 4F, Fifth Edition;
- l) PSL 2, if applicable; and
- m) supplementary information as specified in the particular SR, if applicable (see [Annex A](#)).

5.5 Crown Block Assembly Nameplate Information (Required Only for Crown Block Assemblies for Use with Derricks)

The following information shall be provided:

- a) manufacturer's name;
- b) manufacturer's address;
- c) date of manufacture, including month and year;
- d) serial number;
- e) maximum rated static hook load, KN (short tons);
- f) API 4F, Fifth Edition;
- g) PSL 2, if applicable; and
- h) supplementary information as specified in the particular SR, if applicable (see [Annex A](#)).

6 Structural Safety Level

Drilling structures are qualified according to their SSL. The selection of the expected or the unexpected SSL (e.g. SSL E2/U1) is, by agreement, between the manufacturer and the purchaser for each specific location. For a given SSL and location, the design environmental conditions may be developed from the guidelines that follow.

The SSL level reflects various degrees of consequence of failure, considering life safety and other concerns such as pollution, economic loss, and public concern. It also reflects the expectation (expected or unexpected) of the environmental event. These SSLs are shown in [Table 1](#) below. Each structure will have two SSLs, the first for the expected environmental event, the second for the unexpected environmental event (e.g. SSL E2/U1).

Table 1—Structural Safety Levels for Drilling Structures

Life Safety	Other Concerns (Pollution, Economic Loss, Public Concern, etc.)		
	High	Medium	Low
High	E1 or U1 ^a	E1 or U1 ^a	E1 or U1 ^a
Medium	E1 or U1 ^a	E2 or U2 ^b	E2 or U2 ^b
Low	E1 or U1 ^a	E2 or U2 ^b	E3 or U3 ^c
^a Structural Safety Level E1 or U1—Structures with high consequences of failure. ^b Structural Safety Level E2 or U2—Structures with medium consequences of failure. ^c Structural Safety Level E3 or U3—Structures with low consequences of failure.			

The prefix E refers to an *expected* environmental event, such as a large hurricane or storm, where preparation can be made prior to the event. The prefix U refers to an *unexpected* environmental event, such as a sudden storm or earthquake, which does not allow for sufficient preparations. When a structure is evacuated in advance of an expected severe event, the SSL for the manned event may differ from the SSL for the evacuated severe event.

Transportable Drilling “Nonstationary” Structures—Drilling structures are commonly used in different locations during their lifetime, and the evaluation of their suitability for use in a given location must therefore account for the environmental conditions at that location, installation elevation, and the SSL of the new installation.

For identical SSLs, the design wind load for a *derrick* or *mast* is no different whether it is on a fixed or mobile installation (e.g. platform rig, jack-up, semi-submersible, or drillship).

7 Design Loading

Each drilling structure shall be designed for combinations of loads in accordance with [Table 2](#) or [Table 3](#), as applicable. The structures shall be designed to meet or exceed these conditions in accordance with the applicable design specifications of [Section 8](#).

Table 2—Design Loadings for Drilling Structures ^a

Case	Design Loading Condition	Dead Load ^b (%)	Hook Load ^{c d} (%)	Rotary Load (%)	Setback Load ^{d e} (%)	Environmental Loads ^f
1a	Operating	100	100	0	100	100 % operating environment
1b	Operating	100	TE	100	100	100 % operating environment
2	Expected	100	TE	100	0	100 % expected storm environment
3a	Unexpected	100	TE	100	100	100 % unexpected storm environment
3b	Unexpected	100	As applicable	As applicable	As applicable	100 % earthquake
4	Erection	100	As applicable	As applicable	0	100 % erection environment
5	Transportation	100	As applicable	As applicable	As applicable	100 % transportation environment

^a Excludes service rig masts (see [Table 3](#)).

^b For stability calculations, lower values of dead load shall be considered as in [8.10](#).

^c For nonoperating wind environments, the weight of all traveling equipment and drill lines suspended from the crown (TE) shall be considered in all load cases, as applicable.

^d Substructures that do not support a mast or derrick need not be designed for hook load. Similarly, substructures that do not support setback need not be designed for setback load.

^e Pipe lean is a component of setback loading that shall be considered.

^f Environmental loads include the full design sail area for setback in racking platform, if applicable.

Table 3—Design Loadings for Service Rig Masts

Case	Design Loading Condition	Dead Load ^a (%)	Hook Load ^b (%)	Rod Load (%)	Setback Load (%)	Environmental Loads ^c
1a	Operating	100	100	0	0	100 % operating environment
1b	Operating	100	TBD	100	0	100 % operating environment
1c	Operating	100	TBD	100	100	100 % operating environment
2	Expected	100	TE	0	0	100 % expected storm environment
3a	Unexpected	100	TE	100	100	100 % unexpected storm environment
3b	Unexpected	100	As applicable	As applicable	As applicable	100 % earthquake
4	Erection	100	As applicable	0	0	100 % erection environment
5	Transportation	100	As applicable	As applicable	As applicable	100 % transportation environment

^a For stability calculations, lower values of dead load shall be considered as in [8.10](#).

^b For nonoperating wind environments, the weight of all traveling equipment and drill lines suspended from the crown (TE) shall be considered in all load cases, as applicable.

^c Environmental loads include the full design sail area for setback and rods in the racking platform or rod board, if applicable.

8 Design Specification

8.1 Allowable Strength

8.1.1 General

The steel structures shall be designed in accordance with the Allowable Strength Design code in ANSI/AISC 360-16, except as further specified in this standard. ANSI/AISC 360-16 shall be used in determining allowable member strength. Use of load factor and resistance design (LFRD) is not allowed. ANSI/AISC 360-16 shall be used for determination of allowable member strength except that current practice and experience do not dictate the need to follow ANSI/AISC 360-16 for “members and their connections subject to fatigue loading” (Section B3.11) unless specified by the purchaser and for the consideration of secondary loads.

NOTE Derricks, masts, and substructures for drilling rigs fall outside the defined scope of the ANSI/AISC 360-16 specification. AISC recognizes this and recommends that the use of the AISC specification outside of the defined scope be used with engineering judgement as it relates to the specific industry.

For the purposes of this standard, axial loads (tension or compression) are defined as primary loads in individual members of a latticed or trussed structure. Moments in the individual members of a latticed or trussed structure resulting from elastic deformations and rigidity of joints are defined as secondary loads. These secondary loads may be taken to be the differences between loads from an analysis assuming fully rigid joints, with loads applied only at the joints, and those loads from a similar analysis with pinned joints.

Loads arising from eccentric joint connection, or from transverse loading of members between joints, or from applied moments shall be considered primary loads.

When axial loads are the intended primary loads, allowable member strength may be increased by 10 %. This shall apply to members that have a plastic section modulus/elastic section modulus (Z/S) ratio of 1.2 or less when secondary loads are computed and added to the primary loads in individual members, for all loadings except earthquake. The 10 % increase in allowable member strength shall not be used when the Z/S ratio exceeds 1.2. The Z/S ratio is taken about either the major or minor member axis for the direction of the applied moment. Required strength due to primary loads shall not exceed the maximum allowable member strength. The increase in allowable member strength when secondary loads are considered may be taken in addition to the increases allowed in [8.1.2](#).

The allowable member strength is defined in ANSI/AISC 360–16 as the nominal strength (R_n) of the member divided by a safety factor (Ω). Allowable Strength = R_n / Ω . ANSI/AISC 360-16, Chapters D through K give further definition of the nominal strength and safety factor for the applicable limit states.

Earthquake loading and the related allowable strength are addressed specifically in [8.6](#). Ice Loading and related allowable strength are addressed specifically in [8.7](#).

8.1.2 Wind and Dynamic Allowable Strength Increases

For operating and erection conditions, allowable member strength shall not be increased (strength modifier = 1.0) over the basic allowable member strength defined in [8.1.1](#).

For transportation conditions, allowable member strength may be increased one-third (strength modifier = 1.33) over the basic allowable member strength defined in [8.1.1](#).

For the unexpected and expected design storm conditions, allowable member strength may be increased one-third (strength modifier = 1.33) over basic allowable member strength defined in [8.1.1](#).

For purposes of defining the nameplate graph of allowable static hook load vs wind velocity required by [5.2 n\)](#) or [5.3 o\)](#), a linear transition from a strength modifier of 1.0 for operating cases to 1.33 for the unexpected storm case may be used.

8.1.3 Wire Rope

The size and type of wire shall be as specified in API 9A and by API 9B.

A drilling structure raised and lowered by means of a wire rope assembly shall have the wire rope assembly designed to have a nominal strength of at least 2.5 times the maximum design load on the assembly during erection.

Guy lines shall be designed to have a nominal wire rope assembly strength of at least 2.5 times the maximum guy load resulting from a loading condition.

The strength of a wire rope assembly shall be derated for end connection efficiencies and for D/d ratios less than 18 in accordance with API 9B.

8.1.4 Crown Shafting

Crown shafts, including fastline and deadline sheave support shafts, shall be designed using an allowable stress method with a maximum allowed bending moment as in Equation (1).

$$\text{Maximum allowed bending moment} = 0.60 F_y S \quad (1)$$

where

F_y = Specified Minimum Yield Strength of shaft material, psi

S = Elastic Section Modulus, in^3

Wire rope sheaves and bearings shall be specified in accordance with API 8C.

8.1.5 Hydraulic Cylinders for Mast and Substructure Erection

8.1.5.1 Hydraulic cylinders that are used for mast and/or substructure erection shall be designed for the buckling, combined bending moments, axial loads, and internal pressure over the entire raising and lowering envelope.

8.1.5.2 The rig designer shall calculate the loads applied to the cylinder. These loads applied to the cylinder shall include, at a minimum, the effects of:

- a) structural dead loads;
- b) specified equipment and appurtenances that are supported by the mast and substructure during the raising and lowering condition;
- c) wind loads acting on the structure as specified in 8.4;
- d) allowable variation in cylinder mounting location during operation;
- e) allowable extension offset and the resulting load variations that may occur between multiple cylinders that share a load;
- f) other loads as agreed to between the rig designer and rig purchaser.

8.1.5.3 The rig designer shall supply the following information to the cylinder designer and cylinder manufacturer:

- a) applied cylinder loads over the entire raising and lowering envelope;