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10431

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1993-12-15

Petroleum and natural gas industries — Pumping units — Specification

*Industries du pétrole et du gaz naturel — Unités de pompage —
Spécifications*



Reference number
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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 10431 was prepared by the American Petroleum Institute (API) (as Spec 11E, 16th edition) and was adopted, under a special "fast-track procedure", by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum and natural gas industries*, in parallel with its approval by the ISO member bodies.

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Introduction

International Standard ISO 10431:1993 reproduces the content of API Spec 11E, 16th edition, 1989 and its supplement 1 (July 1, 1991). ISO, in endorsing this API document, recognizes that in certain respects the latter does not comply with all current ISO rules on the presentation and content of an International Standard. Therefore, the relevant technical body, within ISO/TC 67, will review ISO 10431:1993 and reissue it, when practicable, in a form complying with these rules.

This standard is not intended to obviate the need for sound engineering judgement as to when and where this standard should be utilized and users of this standard should be aware that additional or differing requirements may be needed to meet the needs for the particular service intended.

Standards referenced herein may be replaced by other international or national standards that can be shown to meet or exceed the requirements of the referenced standards.

Appendix G to this document shall not be considered as requirements.

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Petroleum and natural gas industries — Pumping units — Specification

1 Scope

This International Standard lays down specification covering the design and rating of pumping units.

2 Requirements

Requirements are specified in:

"API Specification 11E (Spec 11E), Sixteenth Edition, October 1, 1989 — *Specification for Pumping Units*", which is adopted as ISO 10431.

For the purposes of international standardization, however, modifications shall apply to specific clauses and paragraphs of publication API Spec 11E. These modifications are outlined below.

Throughout publication API Spec 11E, the conversion of English units shall be made in accordance with ISO 31, parts 1 and 3. In particular,

LENGTH	1 inch (in)	= 25,4 mm (exactly)
	1 foot (ft)	= 304,8 mm (exactly)
MASS	1 pound (lb)	= 0,453 592 37 kg (exactly)
PRESSURE	1 pound-force per square inch (lbf/in ²) or 1 psi	= 6 894,76 Pa
VOLUME	1 cubic inch (in ³)	= 16,387 064 · 10 ⁻³ dm ³ (exactly)
AREA	1 square inch (in ²)	= 645,16 mm ² (exactly)
VELOCITY	1 foot per second (ft/s)	= 0,304 8 m/s (exactly)
TORQUE	1 inch pound-force (in·lbf)	= 0,112 985 N·m

Page 11

Information given in the POLICY is relevant to the API publication only.

Page 64

Appendix G

Information relating to the use of API monogram is relevant to the API publication only.

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Specification for Pumping Units

API SPECIFICATION 11E (SPEC 11E)
SIXTEENTH EDITION, OCTOBER 1, 1989

American Petroleum Institute
1220 L Street, Northwest
Washington, DC 20005



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Supplement 1
(July 1, 1991)

Specification for Pumping Units

API SPECIFICATION 11E (SPEC 11E)
SIXTEENTH EDITION, OCTOBER 1, 1989

American Petroleum Institute
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Foreword

This supplement contains revisions authorized at the 1990 Standardization Conference as reported in Circ PS-1920 and approved by letter ballot.

Page 5. Replace Par. 2.4 and Fig. 2.1 with the following:

2.4 Walking Beam. The following formula shall be used for rating conventional walking beams as shown in Fig. 2.1.

$$W = \frac{f_{cb}}{A} S_x$$

Wherein:

W = walking-beam rating in pounds of polished-rod load.

f_{cb} = compressive stress in bending in pounds per square inch. See Table 2.1 for maximum allowable stress.

S_x = section modulus in cubic inches. The gross section of the rolled beam may be used except that holes or welds are not permissible on the tension flange in the critical zone. See Fig. 2.1.

A = distance from centerline of saddle bearing to centerline of well in inches. See Fig. 2.1.

C = distance from centerline of saddle bearing to centerline of equalizer bearing in inches. See Fig. 2.1.

Page 6. Replace the equation in Column 4, Row 2 of Table 2.1 with:

$$* \frac{\sqrt{E I_y G J}}{S_x l}$$

Delete all the nomenclature at the end of Table 2.1 and replace it with:

* Where:

J = Torsional constant, in⁴

l = Longest laterally, unbraced length of beam, inches (longer of A or C (See Fig. 2.1)).

E = Modulus of elasticity; 29,000,000 psi.

I_y = Weak axis moment of inertia, in⁴.

G = Shear modulus; 11,200,000 psi.

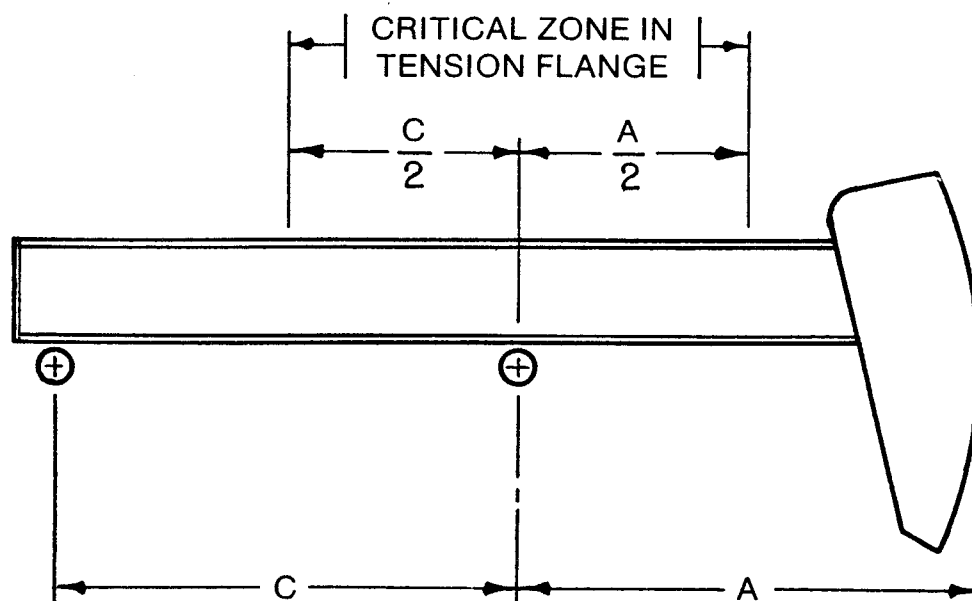


FIG. 2.1
WALKING-BEAM ELEMENTS

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Note

This edition supersedes the fifteenth edition of Spec 11E. It includes changes adopted at the 1988 Standardization Conference as reported in Circ PS-1858 and subsequently passed by letter ballot.

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API SPECIFICATION FOR PUMPING UNITS

Foreword

a. This specification is under the jurisdiction of the Committee on Standardization of Production Equipment.

b. This specification covers designs and ratings of beam-type pumping-unit components. It does not cover chemical properties of materials, nor the use of the equipment.

c. Approved forms are given in Appendix A for rating of crank counterbalances and for recording pumping-unit stroke and torque factors.

d. The following nomenclature is standard:

1. Pumping unit.
2. Pumping-unit structure.

3. Pumping-unit gear reducer.
4. Pumping-unit chain reducer.
5. Pumping-unit beam counterbalance.
6. Pumping-unit crank counterbalance.

e. Attention Users of this Publication: Portions of this publication have been changed from the previous edition. The location of changes has been marked with a bar in the margin. In some cases the changes are significant, while in other cases the changes reflect minor editorial adjustments. The bar notations in the margins are provided as an aid to users to identify those parts of this publication that have been changed from the previous edition, but API makes no warranty as to the accuracy of such bar notations.

SECTION 1
SCOPE

1.1 This specification covers the design and rating of the following:

- a. Pumping-unit structure.
- b. Pumping-unit gear reducer.
- c. Pumping-unit chain reducer.

1.2 American Petroleum Institute (API) Specifications are published as aids to the procurement of standardized equipment and materials, as well as instructions to manufacturers of equipment or materials covered by an API Specification. These Specifications are not intended to obviate the need for sound engineering, nor to inhibit in any way anyone from purchasing or producing products to other specifications.

1.3 The formulation and publication of API Specifications and the API monogram program is not intended in any way to inhibit the purchase of products from companies not licensed to use the API monogram.

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SECTION 2

PUMPING-UNIT STRUCTURES

2.1 Scope. This section covers:

- Standardization of specific structure sizes in combination with established reducer sizes as given in Section 3.
- Walking beam design, with specific rating formula.
- Design loads and limiting working stresses on other structural components are also included.

NOTE: Only loads imposed on the structure and/or gear reducer by the polished rod load are considered in this specification. Additional loads on the pumping unit imposed by add-on devices attached to the reducer, walking beam, or other structural components are not part of this specification. These would include such devices as compressors, stroke increasers, etc.

2.2 No dimensional requirements, other than stroke length, are established. Rating methods are given only for polished-rod capacities; however, allowable working stresses of other structural components for a given polished rod capacity are defined.

Other design criteria such as bearing design, braking capacity, etc., are also established.

2.3 Standard Pumping-Unit Series. It is recommended that pumping units furnished to this specification adhere to the gear reducer rating, structure capacity, and stroke length as given in Table 2.2, although the combinations of these items that make up the pumping unit designation need not be identical to those in the table. The particular combinations in the table are typical but combinations other than those listed are acceptable under this standard.

NOTE: It is the spirit and intent of above provision, that any manufacturer having authority to use the API monogram on pumping-unit structures, may not represent a structure carrying the monogram or for which the letters API or the words "American Petroleum Institute" are used in its description as having a rating of any kind or size other than provided above. This applies to sales information as well as to structure markings.

2.4 Walking Beam. The following formula shall be used for rating conventional walking beams as shown in Fig. 2.1.

$$W = \frac{f_{cb}S}{L}$$

Wherein:

W = walking-beam rating in pounds of polished-rod load.

L = greater of l_f or l_r

f_{cb} = compressive stress in bending in pounds per square inch. See Table 2.1 for maximum allowable stress.

S = section modulus in cubic inches. The gross section of the rolled beam may be used except that holes or welds are not permissible on the tension flange in the critical zone. See Fig. 2.1.

l_f = distance from centerline of saddle bearing to centerline of well in inches. See Fig. 2.1.

l_r = distance from centerline of saddle bearing to centerline of equalizer bearing in inches. See Fig. 2.1.

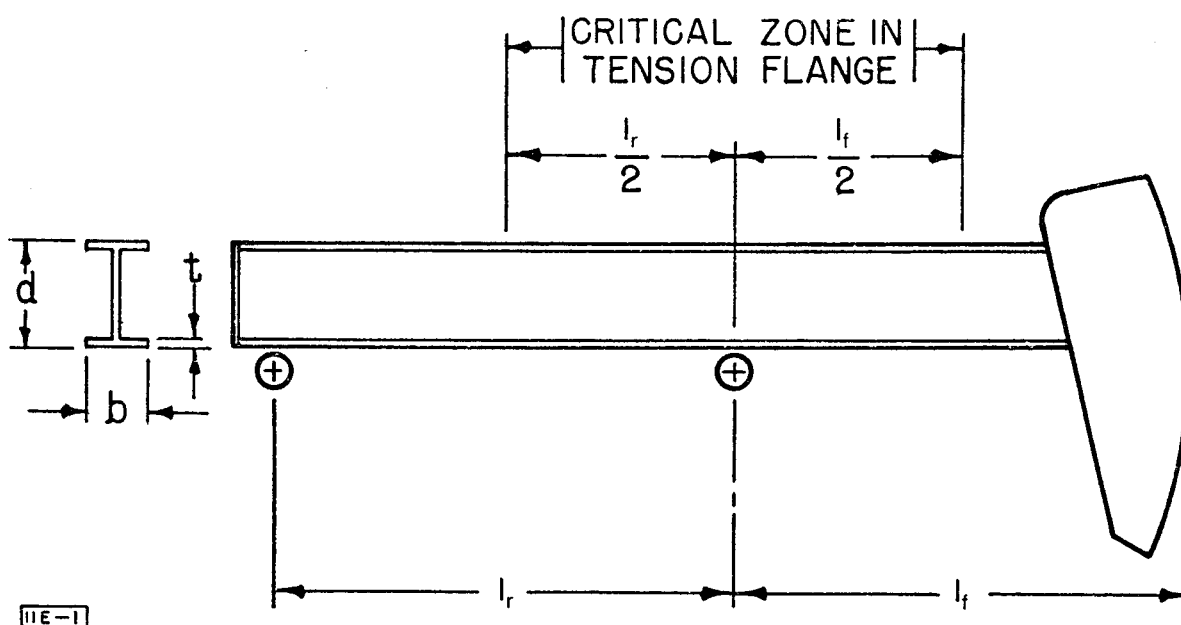


FIG. 2.1
WALKING-BEAM ELEMENTS

TABLE 2.1
MAXIMUM ALLOWABLE STRESSES IN PUMPING-UNIT WALKING BEAMS
 (See Fig. 2.1)

1	2	3	4
	Stress	Symbol	ASTM A36 Structural Steel
1	Tensile stress in extreme fibers in bending, psi.	f_{tb}	11,000
2	Compressive stress in extreme fibers in bending, psi. (May not exceed values on line 3)	f_{cb}	$\frac{*6,000,000}{\frac{ld}{bt}}$
3	Maximum compressive stress in bending, except as limited by equation on line 2, psi.	f_{cb}	11,000
4	Minimum yield strength of material, psi.		36,000

*In the quantity $\frac{l d}{b t}$:

l = longest laterally, unbraced length of beam, inches (longer of l_r or l_f , see Fig. 2.1).

d = depth of beam section, inches.

b = width of compression flange, inches.

t = thickness of compression flange, inches.

NOTE: The formula given in Par. 2.4 is based on the conventional beam construction using a single rolled section. With unconventional construction or built-up sections, due regard shall be given to change in loading, to checking stresses at all critical sections, and to the existence of stress concentrating factors.

2.5 The working stress, f_{cb} , for the beam rating formula given in Par. 2.4, shall be determined from Table 2.1. For standard rolled beams having cross sections symmetrical with the horizontal neutral axis, the critical stress will be compression in the lower flange. The maximum value of this stress, f_{cb} , is the smaller of the values determined from lines 2 and 3 of Table 2.1.

2.6 Unit Rotation. Viewed from the side of the pumping unit with the well head to the right, crank rotation is defined as either clockwise or counter-clockwise.

2.7 Design Loads for All Structural Members Except Walking Beams. For all pumping unit geometries, and unless otherwise specified, use the maximum load exerted on the component in question by examining the loads on the component at each 15° crank position on the upstroke of the pumping unit. Use polished rod load W , for all upstroke crank positions. (See Par. 2.1c)

For units with bi-directional rotation and non-symmetrical torque factors, the direction of rotation for

SPEC 11E	PUMPING-UNIT STRUCTURE
PUMPING UNIT STRUCTURE	
STRUCTURAL UNBALANCE (POUNDS)	
SERIAL NUMBER	
(NAME OF MANUFACTURER)	
(ADDRESS OF MANUFACTURER)	

FIG. 2.2
PUMPING-UNIT STRUCTURE NAME PLATE

NOTE: Structural unbalance is that force in pounds required at the polished rod to hold the beam in a horizontal position with the pitmans disconnected from the crank pins. This structural unbalance is consid-

ered positive when the force required at the polished rod is downward, and negative when upward. The minus (—) sign shall be stamped on the name plate when this value is negative.

design calculations shall be that which results in the highest loading on structural components.

Due consideration shall be given to the direction of loading on all structural bearings and on the structural members supporting these bearings.

NOTE: Allowable stress levels are based on simple stresses without consideration of stress risers. Adequate stress concentration factors shall be used when stress risers occur.

2.8 Design Stresses for All Structural Members Except Walking Beam, Bearing Shafts and Cranks.

- a. Design stresses for all structural components shall be a function of the yield strength of the material, S_y , psi.
- b. Components subjected to simple tension or compression and non-reversing bending shall have a limiting stress of .3 S_y . If stress risers occur in critical zones of tension members, the limiting stress shall be .25 S_y .
- c. Components subjected to reverse bending shall have a limiting stress of .2 S_y .
- d. The following formula shall be used for all components acting as columns:

$$W_2 = \frac{a S_y}{4} \left[1 - \frac{S_y}{4n \pi^2 E} \left(\frac{l}{r} \right)^2 \right]$$

Wherein:

W_2 = maximum applied load on column, lbs.

a = area of cross section, sq. in.

S_y = yield strength of material, psi

n = end restraint constant (assume = 1)

E = modulus of elasticity, psi

l = unbraced length of column, in.

r = radius of gyration of section, in.

$\frac{l}{r}$ shall be limited to a maximum of 90. For $\frac{l}{r}$ values of 30 or less, columns may be assumed to be acting in simple compression (See Par. 2.8b).

2.9 Shafting. All bearing shafts as well as other structural shafting shall have limiting stresses as outlined in Par. 3.8 in the reducer section of this specification.

2.10 Hanger. Wirelines for horseheads shall have a minimum factor of safety of five when applied to the breaking strength of the wireline.

For allowable stresses on carrier bar, end fittings, etc., see Par. 2.8b and 2.8c.

2.11 Brakes. Pumping unit brakes shall have sufficient braking capacity to withstand a torque exerted by the cranks at any crank position with a maximum amount of counterbalance torque designed by the manufacturer for the particular unit involved. This braking torque to be effective with the pumping unit at rest under normal operating conditions with the well disconnected.

NOTE: The pumping unit brake is not intended as a safety stop but is intended for operational stops only.

When operations or maintenance are to be conducted on or around a pumping unit, the position of the crank arms and counterweights should be securely fixed in a stationary position by chaining or other acceptable means.

2.12 Horseheads. Horseheads shall be either hinged or removable to provide access for well servicing.

Horseheads shall be attached to the walking beam in such a manner as to prevent falling off due to a high rod part or other sudden load changes.

The distance from the pivot point of the horsehead to the tangent point of the wireline on the horsehead shall have a maximum dimensional tolerance at any position of the stroke of the following values:

- $\pm \frac{1}{2}$ in. for stroke lengths to 100 in.
- $\pm \frac{3}{8}$ in. for stroke lengths 100 in. to 200 in.
- $\pm \frac{3}{4}$ in. for stroke lengths of 200 in. and longer

2.13 Cranks. All combined stresses in cranks shall be limited to a maximum value of .15 S_y .

2.14 Structural Bearing Design. Structural bearing shafts may be supported in sleeve or anti-friction bearings.

a. Anti-Friction Bearings.

For bearings subject to oscillation or rotation use the bearing load ratio formula:

$$R_1 = k \frac{C_1}{W_1}$$

Where:

- R_1 = bearing load ratio
- k = 1 for bearings rated at 33-1/3 rpm and 500 hours or
- k = 3.86 for bearings rated at 500 rpm and 3000 hours
- C_1 = bearing manufacturer's specific dynamic rating in lbs.
- W_1 = maximum load on bearing in lbs.

For bearings subject to oscillation only use an R_1 value of 2.0 or greater.

For bearings subject to rotation use an R_1 value of 2.25 or greater.

TABLE 2.2
PUMPING UNIT SIZE RATINGS

1	2	3	4	1	2	3	4
Pumping Unit Size	Reducer Rating, in.-lb	Structure Capacity, lb	Max. Stroke Length, in.	Pumping Unit Size	Reducer Rating, in.-lb	Structure Capacity, lb	Max. Stroke Length, in.
6.4—32—16	6,400	3,200	16	320—213—86	320,000	21,300	86
6.4—21—24	6,400	2,100	24	320—256—100	320,000	25,600	100
10—32—24	10,000	3,200	24	320—305—100	320,000	30,500	100
10—40—20	10,000	4,000	20	320—213—120	320,000	21,300	120
16—27—30	16,000	2,700	30	320—256—120	320,000	25,600	120
16—53—30	16,000	5,300	30	320—256—144	320,000	25,600	144
25—53—30	25,000	5,300	30	456—256—120	456,000	25,600	120
25—56—36	25,000	5,600	36	456—305—120	456,000	30,500	120
25—67—36	25,000	6,700	36	456—365—120	456,000	36,500	120
40—89—36	40,000	8,900	36	456—256—144	456,000	25,600	144
40—76—42	40,000	7,600	42	456—305—144	456,000	30,500	144
40—89—42	40,000	8,900	42	456—305—168	456,000	30,500	168
40—76—48	40,000	7,600	48	640—305—120	640,000	30,500	120
57—76—42	57,000	7,600	42	640—256—144	640,000	25,600	144
57—89—42	57,000	8,900	42	640—305—144	640,000	30,500	144
57—95—48	57,000	9,500	48	640—365—144	640,000	36,500	144
57—109—48	57,000	10,900	48	640—305—168	640,000	30,500	168
57—76—54	57,000	7,600	54	640—305—192	640,000	30,500	192
80—109—48	80,000	10,900	48	912—427—144	912,000	42,700	144
80—133—48	80,000	13,300	48	912—305—168	912,000	30,500	168
80—119—54	80,000	11,900	54	912—365—168	912,000	36,500	168
80—133—54	80,000	13,300	54	912—305—192	912,000	30,500	192
80—119—64	80,000	11,900	64	912—427—192	912,000	42,700	192
114—133—54	114,000	13,300	54	912—470—240	912,000	47,000	240
114—143—64	114,000	14,300	64	912—427—216	912,000	42,700	216
114—173—64	114,000	17,300	64	1280—427—168	1,280,000	42,700	168
114—143—74	114,000	14,300	74	1280—427—192	1,280,000	42,700	192
114—119—86	114,000	11,900	86	1280—427—216	1,280,000	42,700	216
160—173—64	160,000	17,300	64	1280—470—240	1,280,000	47,000	240
160—143—74	160,000	14,300	74	1280—470—300	1,280,000	47,000	300
160—173—74	160,000	17,300	74	1824—427—192	1,824,000	42,700	192
160—200—74	160,000	20,000	74	1824—427—216	1,824,000	42,700	216
160—173—86	160,000	17,300	86	1824—470—240	1,824,000	47,000	240
228—173—74	228,000	17,300	74	1824—470—300	1,824,000	47,000	300
228—200—74	228,000	20,000	74	2560—470—240	2,560,000	47,000	240
228—213—86	228,000	21,300	86	2560—470—300	2,560,000	47,000	300
228—246—86	228,000	24,600	86	3648—470—240	3,648,000	47,000	240
228—173—100	228,000	17,300	100	3648—470—300	3,648,000	47,000	300
228—213—120	228,000	21,300	120				

b. Sleeve Bearings.

The design of sleeve bearings is beyond the scope of this specification. It shall be the responsibility of the pumping unit manufacturer to design sleeve bearings, based on available test data and field experience, which are comparable in performance to anti-friction bearings designed for the same operating loads and speeds.

2.15 Installation Markings. Clearly defined and readily usable markings shall be provided on the end cross members of the base to indicate the vertical projection of the walking beam centerline. The markings shall be applied with a chisel, punch, or other suitable tool.

2.16 Marking.* Each pumping-unit structure shall be provided with a name plate substantially as shown in Fig. 2.2. At the discretion of the manufacturer, the

name plate may contain other non-conflicting and appropriate information, such as model number or lubrication instructions.

2.17 In order that the torque on a reducer may be determined conveniently and accurately from dynamometer test data, manufacturers of pumping units shall provide, on request of the purchaser, stroke and torque factors for each 15-deg position of the crank. An approved form for the submission of these data is shown in Appendix A.

*Users of this specification should note that there is no longer a requirement for marking a product with the API monogram. The American Petroleum Institute continues to license use of the monogram on products covered by this specification but it is administered by the staff of the Institute separately from the specification. The policy describing licensing and use of the monogram is contained in Appendix H, herein. No other use of the monogram is permitted.

SECTION 3 PUMPING-UNIT REDUCERS

3.1 SCOPE

Applicability. This Specification is applicable to enclosed speed reducers wherein the involute gear tooth designs include helical and herringbone gearing. This Specification is intended primarily for beam-type pumping units.

Limitations. The rating methods and influences identified in this Specification are limited to single and multiple stage designs applied to oilfield pumping units, in which the pitch-line velocity of any stage does not exceed 5000 feet per minute and the speed of any shaft does not exceed 3600 revolutions per minute.

3.2 RESPONSIBILITY

Gear Reducer Designers. Professionals using this Specification should realize that it is quite difficult to identify and offer solutions to all the influences affecting a gear reducer. For this reason, it is recommended that this Specification be used by engineers with significant experience in mechanical systems.

Reducers rated under this Specification, and properly applied, installed, lubricated and maintained, shall be

capable of safely carrying the rated peak torque under normal oilfield conditions.

Rating Factors. The allowable stress numbers in this Specification are maximum allowed values. Less conservative values for other rating factors in this Specification shall not be used.

Metallurgy. The allowable stress numbers, s_{ac} and s_{at} , included in this Specification are based on commercial ferrous material manufacturing practices. Hardness, tensile strength, and microstructure are the criteria for allowable stress numbers. Reasonable levels of cleanliness and metallurgical controls are required to permit the use of the allowable stress numbers contained in this Specification.

Residual Stress. Any material having a case-core relationship is likely to have residual stresses. If properly managed, these stresses will be compressive and will enhance the bending strength performance of the gear teeth. Shot peening, case carburizing, nitriding, and induction hardening are common methods of inducing compressive prestress in the surface of the gear teeth.

TABLE 3.1
SYMBOLS USED IN GEAR RATING EQUATIONS

Symbol	Description	Reference
A	Tensile Area of Fastener, in. ²	3.8
C _m	Load Distribution Factor for Pitting Resistance	3.5
C _p	Elastic Coefficient	3.5
C ₁	Pitting Velocity Number	3.5
C ₂	Pitting Contact Number	3.5
C ₃	Pitting Stress Number	3.5
C ₅	Velocity Factor for Pitting Resistance	3.5
D	Operating Pitch Diameter of Gear, in.	3.7
D _m	Mean Diameter of Fastener, in.	3.8
d	Operating Pitch Diameter of Pinion, in.	3.5
d _s	Shaft Diameter, in.	3.8
E _G	Modulus of Elasticity for Gear, psi	Table 3.4
E _p	Modulus of Elasticity for Pinion, psi	Table 3.4
F	Net Face Width of Narrowest Member, in.	3.5
H _B	Brinell Hardness	Fig. 3.1
h ₁	Key Height in Shaft or Hub, in.	3.8
I	Geometry Factor for Pitting Resistance	3.5
J	Geometry Factor for Bending Strength	3.6
K _m	Load Distribution Factor for Bending Strength	3.6
K _{ms}	Load Distribution Factor, Static Torque	3.7
K _y	Yield Strength Factor	3.7
K ₁	Strength Velocity Number	3.6
K ₂	Strength Contact Number	3.6
K ₃	Strength Stress Number	3.6
K ₄	Strength Geometry Number	3.6
K ₅	Velocity Factor for Bending Strength	3.6
L	Length of Key, in.	3.8
L _{min}	Minimum Total Length of Lines of Contact in Contact Zone	3.5
m _G	Gear Ratio	3.5
N _G	Number of Teeth in Gear	3.5
N _T	Threads Per Inch of Fastener	3.8
N _p	Number of Teeth in Pinion	3.5
n _o	Speed of Output Shaft, rpm	3.5
n _p	Pinion Speed, rpm	3.5
P _d	Diametral Pitch, Nominal, in the Plane Rotation (Transverse), in. ⁻¹	3.6
P _{nd}	Normal Diametral Pitch, in. ⁻¹	3.6
p _N	Normal Base Pitch, in.	3.5
s _s	Key Shear Stress, psi	Fig. 3.7
s _c	Key Compressive Stress, psi	Fig. 3.7
s _{ac}	Allowable Contact Stress Number, psi	3.5
s _{at}	Allowable Bending Stress Number, psi	3.6
s _{ay}	Allowable Yield Strength Number, psi	3.7
T _t	Shaft Torque Transmitted, lb. in.	3.8
T _{ac}	Allowable Transmitted Torque at Output Shaft Based on Pitting Resistance, lb. in.	3.5
T _{at}	Allowable Transmitted Torque at Output Shaft Based on Bending Strength, lb. in.	3.6
T _{as}	Allowable Static Torque, lb. in.	3.7
T _{as1}	Allowable Static Torque, 1st Reduction, lb. in.	3.7
T _{as2}	Allowable Static Torque, 2nd Reduction, lb. in.	3.7
T _{asn}	Allowable Static Torque, nth Reduction, lb. in.	3.7
v _t	Pitchline Velocity, ft/min	3.5
w	Width of Key, in.	3.8
Z	Length of Line Action in Transverse Plane, in.	3.5
φ _n	Normal Operating Pressure Angle, degrees	3.5
φ _t	Operating Transverse Pressure Angle, degrees	3.5
ψ	Helix Angle at Operating Pitch Diameter	3.5

Grinding the tooth surface after heat treatment may reduce the residual compressive stresses. Grinding the root fillet area may introduce tensile stresses in the root. Care must be taken to avoid changes in micro-structure during the grinding process. Shot peening is often performed after grinding to assure the presence of residual compressive stresses.

System Analysis. A pumping system analysis is the responsibility of the user. This analysis will indicate whether the calculated loading on the gear reducer is within the design limits for which it is offered. A polished rod dynamometer can be used to determine the actual loading on the gear reducer.

Methods of computing or of measuring well loads are not within the scope of this Specification, however, API Recommended Practice API RP11L can be used to predict approximate polished rod loads and gear-reducer torque values. Cognizance should be taken by the user of the possibility of actual loads exceeding apparent loads under one or more of the following conditions:

- (1) Improper counterbalancing.
- (2) Excessive fluctuation in engine power output.
- (3) Serious critical vibrations of the reducer and engine system.
- (4) Poor bottom-hole pump operation.
- (5) Looseness in the pumping-unit structure.

The pumping system includes the prime mover (electric motor, multi-cylinder engine, or single cylinder engine), the pumping unit structure including gear reducer, the sucker rod string, the bottom hole pump, tubing, casing and any other component or condition that influences the loading.

3.3 DEFINITIONS AND SYMBOLS

Definitions. The terms used, wherever applicable, conform to the following standards:

- (1) ANSI Y10.3-1968 "Letter Symbols for Quantities Used in Mechanics of Solids."
- (2) AGMA 112, "Gear Nomenclature, Terms, Definitions, Symbols, and Abbreviations."

Symbols. The symbols used in the pitting resistance and bending strength formulas are shown in Table 3.1.

NOTE: The symbols and definitions used in this Specification may differ from other specifications. Users should assure themselves that they are using these symbols and definitions in the manner indicated herein.

3.4 GEAR RATING TERMINOLOGY

Peak Torque Rating. The peak torque rating of the gear reducer will be the lower of the pitting resistance torque rating, bending strength torque rating, or static

torque ratings as determined by the use of the applicable formulas listed.

Gear ratings as given in the formulas listed are extracted from "AGMA Application Standard for Helical and Herringbone Speed Reducers for Oilfield Pumping Units" (AGMA 422.03), with the permission of the publisher, the American Gear Manufacturers Association, 1901 North Fort Myer Drive, Suite 1000, Arlington, Virginia 22209.

Standard Sizes. The pumping unit reducer of a given size shall have a capacity, calculated as provided herein, as near as practical to, but not less than, the corresponding peak torque rating in Table 3.2.

TABLE 3.2
PUMPING UNIT REDUCER SIZES AND RATINGS

Size	Peak Torque Rating, lb. in.
6.4	6,400
10	10,000
16	16,000
25	25,000
40	40,000
57	57,000
80	80,000
114	114,000
160	160,000
228	228,000
320	320,000
456	456,000
640	640,000
912	912,000
1280	1,280,000
1824	1,824,000
2560	2,560,000
3648	3,648,000

Rating Speeds. Gear ratings shall be based on a nominal pumping speed of 20 strokes per minute up to and including the 320 API gear reducer size (peak torque rating — 320,000 pound inches). On gear reducers with ratings in excess of 320,000 pound inches, the ratings shall be based on the following nominal pumping speeds:

Strokes Per Minute, n_o	Peak Torque Rating Pounds Inches
16	456,000
16	640,000
15	912,000
14	1,280,000
13	1,824,000
11	2,560,000 and larger

3.5 PITTING RESISTANCE TORQUE RATING

Pitting is considered to be a fatigue phenomenon, and is a function of the stresses at the tooth surface.