INTERNATIONAL STANDARD

# ISO 14693

First edition
2003-12-15

# Petroleum and natural gas industries — Drilling and well-servicing equipment

*Industries du pétrole et du gaz naturel — Équipement de forage et d'entretien des puits*

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Reference number
ISO 14693:2003(E)

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Published in Switzerland

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## Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 14693 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 4, *Drilling and production equipment*.

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# Introduction

International Standard ISO 14693 is based upon API Specification 7K (3rd edition).

Users of this International Standard should be aware that further or differing requirements may be needed for individual applications. This International Standard is not intended to inhibit a vendor from offering, or the purchaser from accepting, alternative equipment or engineering solutions for the individual application. This may be particularly applicable where there is innovative or developing technology. Where an alternative is offered, the vendor should identify any variations from this International Standard and provide details.

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# Petroleum and natural gas industries — Drilling and well-servicing equipment

## 1 Scope

This International Standard provides general principles and specifies requirements for design, manufacture and testing of new drilling and well-servicing equipment and of replacement primary load-carrying components manufactured subsequent to the publication of this International Standard.

This International Standard is applicable to the following equipment:

a) rotary tables;

b) rotary bushings;

c) rotary slips;

d) rotary hoses;

e) piston mud-pump components;

f) drawworks components;

g) spiders not capable of use as elevators;

h) manual tongs;

i) safety clamps not used as hoisting devices;

j) power tongs, including spinning wrenches.

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Annex A gives a number of standardized supplementary requirements which apply only when specified.

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 148, *Steel — Charpy impact test (V-notch)*

ISO 6892, *Metallic materials — Tensile testing at ambient temperature*

ISO 7500-1, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system*

API Spec 5B, *Specification for threading, gaging and thread inspection of casing, tubing, and line pipe threads*

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ANSI/AGMA[1) ] 2004-B89, *Gear Materials and Heat Treatment Manual*

ANSI[2)]/ASME[3)] B1.1, *Unified Inch Screw Threads (UN and UNR Thread Form)*

ANSI/ASME B1.2, *Gages and Gaging for Unified Inch Screw Threads*

ANSI/AWS[4)] D1.1, *Structural Welding Code — Steel*

ASME Boiler and Pressure Vessel Code Section V, *Nondestructive Examination*

ASME Boiler and Pressure Vessel Code Section VIII, *Alternative Rules for Construction of High Pressure Vessels*

ASME Boiler and Pressure Vessel Code Section IX, *Welding and Brazing Qualifications*

ASNT[5)] TC-1A, *Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing*

ASTM[6)] A 370, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

ASTM A 388, *Standard Practice for Ultrasonic Examination of Heavy Steel Forgings*

ASTM A 751, *Standard Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products*

ASTM A 770, *Standard Specification for Through-Thickness Tension Testing of Steel Plates for Special Applications*

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ASTM E 4, *Standard Practices for Force Verification of Testing Machines*

ASTM E 125, *Standard Reference Photographs for Magnetic Particle Indications on Ferrous Castings*

ASTM E 165, *Standard Test Method for Liquid Penetrant Examination*

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ANSI/ASTM E 186, *Standard Reference Radiographs for Heavy-Walled (2 to 4 1/2-in. (51 to 114-mm)) Steel Castings*

ANSI/ASTM E 280, *Standard Reference Radiographs for Heavy-Walled (4 1/2 to 12-in. (114 to 305-mm)) Steel Castings*

ASTM E 428, *Standard Practice for Fabrication and Control of Steel Reference Blocks Used in Ultrasonic Examination*

ANSI/ASTM E 446, *Standard Reference Radiographs for Steel Castings Up to 2 in. (51 mm) in Thickness*

ASTM E 709, *Standard Guide for Magnetic Particle Examination*

AWS QC1, *Certification of Welding Inspectors*

EN 287 (all parts), *Approval testing of welders — Fusion welding*

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1) American Gear Manufacturers Association, 1500 King Street, Suite 201, Alexandria, VA 22314, USA.

2) American National Standards Institute, 1430 Broadway, New York, NY 10018, USA

3) American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017, USA.

4) American Welding Society, 550 N.W. LeJeune Road, Box 351040, Miami, FL 33135, USA.

5) American Society for Nondestructive Testing, 4153 Arlingate Plaza, Box 28518, Columbus, OH 43228, USA.

6) American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428, USA.

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MSS[7] SP-53, *Quality Standard for Steel Castings and Forgings for Valves, Flanges and Fittings and other Piping Components — Magnetic Particle Examination Method*

MSS SP-55, *Quality Standard for Steel Castings for Valves, Flanges and Fittings and other Piping Components- Visual Method for Evaluation of Surface Irregularities*

## 3 Terms, definitions and abbreviated terms

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

### 3.1 Terms and definitions

**3.1.1**
**critical area**
highly stressed regions on a primary load-carrying component

**3.1.2**
**design load**
sum of the static and dynamic loads that would induce the maximum allowable stress in the equipment

**3.1.3**
**design safety factor**
factor to account for a certain safety margin between the maximum allowable stress and the minimum specified yield strength of the material

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**3.1.4**
**design verification test**
test undertaken to validate the integrity of the design calculations used

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**3.1.5**
**dynamic load**
load applied to the equipment due to acceleration effects

**3.1.6**
**equivalent round**
**ER**
standard for comparing variously shaped sections to round bars, used in determining the response to hardening characteristics when heat-treating low-alloy and martensitic corrosion-resistant steels

**3.1.7**
**identical design concept**
property of a family of units whereby all units of the family have similar geometry in the primary load-carrying areas

**3.1.8**
**linear indication**
indication, revealed by non-destructive examination, having a length at least three times its width

**3.1.9**
**maximum allowable stress**
specified minimum yield strength divided by the design safety factor

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7) Manufacturers Standardization Society of the Valve and Fittings Industry; 127 Park Street NE; Vienna, VA 22180; USA.

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**3.1.10**
**primary load**
load that arises within the equipment when the equipment is performing its primary design function

**3.1.11**
**primary load-carrying component**
component of the equipment through which the primary load is carried

**3.1.12**
**proof load test**
production load test undertaken to validate the structural soundness of the equipment

**3.1.13**
**rated load**
maximum operating load, both static and dynamic, to be applied to the equipment

NOTE The rated load is numerically equivalent to the design load.

**3.1.14**
**rated speed**
rate of rotation, motion or velocity as specified by the manufacturer

**3.1.15**
**repair**
removal of defects from, and refurbishment of, a component or assembly by welding during the manufacturing process

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NOTE The term "repair", as referred to in this International Standard, applies only to the repair of defects in materials during the manufacture of new equipment.

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**3.1.16**
**rounded indication**
indication, revealed by nondestructive examination, with a circular or elliptical shape and having a length less than three times its width

**3.1.17**
**safe working load**
design load reduced by the dynamic load

**3.1.18**
**size class**
designation of the dimensional interchangeability of equipment specified herein

**3.1.19**
**size range**
range of tubular diameters to which an assembly is applicable

**3.1.20**
**special process**
operation that may change or affect the mechanical properties, including toughness, of the materials used in the equipment

**3.1.21**
**test unit**
prototype unit upon which a design verification test is conducted


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### 3.2 Abbreviated terms

HAZ heat-affected zone

NDE non-destructive examination

PWHT post-weld heat treatment

TIR total indicated runout

## 4 Design

### 4.1 Design conditions

Drilling equipment shall be designed, manufactured and tested such that it is in every respect fit for its intended purpose. The equipment shall safely transfer the load for which it is intended. The equipment shall be designed for safe operation.

The following design conditions shall apply:

— the design load and the safe working load are defined as in Clause 3. The operator of the equipment shall be responsible for the determination of the safe working load for specific operations;

— unless changed by a supplementary requirement (see Annex A, SR2 and SR2A), the design and minimum operating temperature for rotary tables, rotary slips, power tongs and drawworks is 0 °C (32 °F). The design and minimum operating temperature for safety clamps, spiders and manual tongs is –20 °C (–4 °F), unless changed by a supplementary requirement.

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**CAUTION — Use of equipment covered by this International Standard at rated loads and temperatures below the design temperatures noted above is not recommended unless appropriate materials with the required toughness properties at lower design temperatures have been used in the manufacture of the equipment (see Annex A, SR2 and SR2A).**

### 4.2 Strength analysis

#### 4.2.1 General

The equipment design analysis shall address excessive yielding, fatigue or buckling as possible modes of failure.

The strength analysis shall be based on the elastic theory. Alternatively, ultimate strength (plastic) analysis may be used where justified by design documentation.

All forces that may govern the design shall be taken into account. For each cross-section to be considered, the most unfavorable combination, position, and direction of forces shall be used.

#### 4.2.2 Simplified assumptions

Simplified assumptions regarding stress distribution and stress concentration may be used, provided that assumptions are made in accordance with generally accepted practice or based on sufficiently comprehensive experience or tests.

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#### 4.2.3 Empirical relationships

Empirical relationships may be used in lieu of analysis, provided such relationships are supported by documented strain gauge test results that verify the stresses within the component. Equipment or components which, by their design, do not permit the attachment of strain gauges to verify the design shall be qualified by testing in accordance with 5.6.

#### 4.2.4 Equivalent stress

The strength analysis shall be based on elastic theory. The nominal equivalent stress, according to the Von Mises-Hencky theory, caused by the design load shall not exceed the maximum allowable stress $\sigma_{\text{allow}}$ as calculated by Equation (1).

$$\sigma_{\text{allow}} = \frac{S_{\text{Ymin}}}{F_{\text{DS}}} \tag{1}$$

where

$S_{\text{Ymin}}$ is the specified minimum yield strength;

$F_{\text{DS}}$ is the design safety factor.

#### 4.2.5 Ultimate strength (plastic) analysis

An ultimate strength (plastic) analysis may be performed under any one of the following conditions:

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a) for contact areas;

b) for areas of highly localized stress concentrations caused by part geometry, and other areas of high stress gradients where the average stress in the section is less than or equal to the maximum allowable stress as defined in 4.2.4.

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In such areas, the elastic analysis shall govern for all values of stress below the average stress.

In the case of plastic analysis, the nominal equivalent stress according to the Von Mises-Hencky theory shall not exceed the maximum allowable stress $\sigma_{\text{allow}}$ as calculated by Equation (2).

$$\sigma_{\text{allow}} = \frac{S_{\text{ULTmin}}}{F_{\text{DS}}} \tag{2}$$

where

$S_{\text{ULTmin}}$ is the specified minimum ultimate tensile strength;

$F_{\text{DS}}$ is the design safety factor.

#### 4.2.6 Stability analysis

The stability analysis shall be carried out according to generally accepted theories of buckling.

#### 4.2.7 Fatigue analysis

The fatigue analysis shall be based on a time period of not less than 20 years, unless otherwise agreed.

The fatigue analysis shall be carried out according to generally accepted theories. A method that may be used is defined in reference [3].


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## 4.3 Size class designation

The size class designation for equipment shall represent dimensional interchangeability in accordance with Clause 9.

## 4.4 Rating

**4.4.1** Rotary tables, spiders, manual and power tongs furnished under this International Standard shall be rated in accordance with the requirements specified herein.

**4.4.2** The static ratings for all bearings within the primary load path shall meet or exceed the rated load for the equipment.

**4.4.3** Power and manual tongs shall be assigned torque ratings by the manufacturer for all configurations for which the tong is designed.

## 4.5 Load rating basis

The load rating shall be based on:

a) the design safety factor as specified in 4.6;

b) the minimum specified yield strength of the material used in the primary load-carrying components;

c) the stress distribution as determined by design calculations and/or data developed in a design verification load test as specified in 5.6.

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## 4.6 Design safety factor

**4.6.1** Design safety factor for spiders shall be established as follows:

| **Load rating**<br>$R$ | **Design safety factor**<br>$F_{DS}$ |
|---|---|
| < 1 334 kN (150 short tons) | 3,00 |
| 1 334 kN to 4 448 kN (150 short tons to 500 short tons) inclusive | $3,00 - 0,75(R - 1\,334)/3\,114$ [a]<br>$3,00 - 0,75(R - 150)/350$ [b] |
| > 4 448 kN (500 short tons) | 2,25 |

[a] In this formula, the value of $R$ shall be expressed in SI units of kilonewtons.

[b] In this formula, the value of $R$ shall be expressed in USC units of short tons.

The design safety factor is intended as a design criterion and shall not under any circumstances be construed as allowing loads on the equipment in excess of the rated load.

**4.6.2** The minimum design safety factor of structural components in the primary load path of rotary tables shall be 1,67.

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**4.6.3** The minimum design safety factor for manual tongs, jaws, and snub-line attachments of power tongs shall be established as follows:

| **Torque rating**<br>$R$ | **Design safety factor**<br>$F_{DS}$ |
|---|---|
| $\leqslant$ 41 kN·m (30 $\times$ $10^3$ ft-lb) | 3,00 |
| $>$ 41 kN·m (30 $\times$ $10^3$ ft-lb) to 136 kN·m (100 $\times$ $10^3$ ft-lb) | 3,00 – 0,75 ($R$ – 41)/95[a]<br>3,00 – 0,75($R$ – 30 $\times$ $10^3$)/(70 $\times$ $10^3$)[b] |
| $\geqslant$ 136 kN·m (100 $\times$ $10^3$ ft-lb) | 2,25 |

[a] In this formula, the value of $R$ shall be expressed in SI units of kilonewton metres.

[b] In this formula, the value of $R$ shall be expressed in USC units of foot-pounds.

## 4.7 Shear strength

For purposes of design calculations involving shear, the ratio of yield strength in shear to yield strength in tension shall be 0,58.

## 4.8 Specific equipment

See Clause 9 for equipment-specific design requirements.

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## 4.9 Design documentation

Documentation of design shall include methods, assumptions, calculations, and design requirements. Design requirements shall include but not be limited to those criteria for size, test and operating pressures, material, environmental and specification requirements, and other pertinent requirements upon which the design is to be based.

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The requirements also apply to design change documentation.

# 5 Design verification

## 5.1 General

To ensure the integrity of the design and supporting calculations, equipment shall be subject to design verification testing when required in Clause 9.

Design verification testing shall be performed in accordance with documented procedures.

Design verification testing shall be carried out or certified by personnel who are independent of those having direct responsibility for the design and manufacture of the product and are qualified to perform their task.

Design verification testing may consist of one or more of the listed tests as required by the specific equipment clauses of this International Standard:

a) function testing;

b) pressure testing;

c) load testing.


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## 5.2 Design verification function test

### 5.2.1 Sampling of test units

One unit of each model of equipment shall be subjected to function testing if the equipment transmits force, motion or energy by means of continued movement of the equipment parts.

### 5.2.2 Test procedure

The manufacturer shall establish a procedure documenting the duration, applied load and speed of the test. For equipment designed for continuous operation, the test unit shall be operated at rated speed for a minimum of 2 h. For equipment designed for intermittent or cyclical operation, the test unit shall be operated at rated speed and established duty cycles equivalent to 2 h operation or ten duty cycles, whichever is greater, unless otherwise specified by Clause 9.

### 5.2.3 Qualification

The unit shall operate without noted loss of power. The temperature of the bearings and lubrication oil shall be within acceptable limits as established by the design and documented in the test procedure.

## 5.3 Design verification pressure test

### 5.3.1 Sampling of test units

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Each design of pressure-containing items or, as defined in Clause 9, primary load-carrying components, where the primary load is pressure, shall be hydrostatically tested for design verification. Hydraulic power transmission components are excluded from this test.

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### 5.3.2 Test procedure

The test pressure shall be 1,5 times the maximum rated operating pressure. Cold water, water with additives, or the fluid normally used in actual service shall be used as the test fluid. Tests shall be performed on the completed part or assembly before painting.

The hydrostatic test shall be applied for two cycles. Each cycle shall consist of the following four steps:

a) the primary pressure-holding period;

b) the reduction of the test pressure to zero;

c) thorough drying of all external surfaces of the item being tested;

d) the secondary pressure-holding period.

The pressure-holding periods shall not start until the test pressure has been reached, and the equipment and pressure-monitoring gauge isolated from the pressure source. The pressure-holding periods shall not be less than 3 min.

### 5.3.3 Qualification

After each test cycle, the test item shall be carefully inspected for the absence of leakage or permanent deformation. Failure to meet this requirement, or premature failure, shall be the cause for a complete reassessment of the design, followed by repetition of the test.

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