Closed Die Forgings for Use in the Petroleum and Natural Gas Industry

API SPECIFICATION 20C
FIRST EDITION, OCTOBER 2009

EFFECTIVE DATE: APRIL 1, 2010

ADDENDUM 1, JULY 2014

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Upstream Segment

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Contents

Closed Die Forgings for Use in the Petroleum and Natural Gas Industry

1 Scope

1.1 Purpose

This standard specifies requirements and gives recommendations for the design, qualification, and production of closed die forgings for use in API service components in the petroleum and natural gas industries when referenced by an applicable equipment standard or otherwise specified as a requirement for compliance.

1.2 Applicability

This standard is applicable to equipment used in the oil and natural gas industries where service conditions warrant the use of closed die forgings. Examples include pressure-containing or load-bearing components.

1.3 Forging Specification Levels (FSLs)

This standard establishes requirements for four FSLs. These FSL designations define different levels of forged product technical, quality, and qualification requirements.

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.

API Specification 6A, *Specification for Wellhead and Christmas Tree Equipment*

ASTM A370 [1], *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

ASTM A604, *Standard Practice for Macroetch Testing of Consumable Electrode Remelted Steel Bars and Billets*

ASTM E10, *Standard Test Method for Brinell Hardness of Metallic Materials*

ASTM E18, *Standard Test Methods for Rockwell Hardness of Metallic Materials*

ASTM E45, *Standard Test Method for Determining the Inclusion Content of Steel*

ASTM E110, *Standard Test Method for Indentation Hardness of Metallic Materials by Portable Hardness Testers*

ASTM E112, *Standard Test Methods for Determining Average Grain Size*

ASTM E381, *Standard Method of Macroetch Testing Steel Bars, Billets, Blooms, and Forgings*

ISO 2859-1 [2], *Sampling procedures for inspection by attributes—Part 1: Sampling plans indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

NCSL Z540.3 [3], *Requirements for the Calibration of Measuring and Test Equipment*

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1 ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.
2 International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, www.iso.org.
3 NCSL International, 2995 Wilderness Place, Suite 107, Boulder, Colorado 80301-5404, www.ncsli.org.

MSS SP-55 [4], *Quality Standard for Steel Castings for Valves, Flanges, Fittings and Other Piping Components—Visual Method for Evaluation of Surface Irregularities*

3 Terms, Definitions, Acronyms, and Abbreviations

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

3.1 Terms and Definitions

3.1.1
acceptance criteria
Defined limits placed on characteristics of materials, processes, products, or services.

3.1.2
as-forged
The condition of a forging as it comes out of the finisher cavity without any subsequent operations.

3.1.3
billet
A semi-finished, cogged, hot-rolled, or continuous-cast metal product of uniform section, usually rectangular with radiused corners.

NOTE 1 Billets are relatively larger than bars.

NOTE 2 Also see **bloom**.

3.1.4
blank
multiple
slug
Raw material or forging stock from which a forging is made.

3.1.5
bloom
A semi-finished product of square, rectangular, or even round cross section, hot rolled, continuously cast, or forged.

NOTE 1 For steel, the width of a bloom is not more than twice the thickness, and the cross-sectional area is usually not less than approximately 36 $in.^2$.

NOTE 2 No invariable rule prevails for distinguishing between blooms and billets; the terms are frequently used interchangeably.

3.1.6
calibration
Comparison and adjustment to a standard of known accuracy.

3.1.7
closed die forging
The shaping of hot metal completely within the walls or cavities of two dies that come together to enclose the work piece on all sides.

NOTE The impression for the forging can be entirely in either die or divided between the top and bottom dies. Impression die forging, often used interchangeably with the term closed die forging, refers to a closed die operation in which the dies contain a provision for controlling the flow of excess material, or flash, that is generated.

[4] Manufacturers Standardization Society of the Valve and Fittings Industry, Inc., 127 Park Street, NE, Vienna, Virginia 22180-4602, www.mss-hq.com.

3.1.8
cold shut
fold
lap
A defect such as lap that forms whenever metal folds over itself during forging.

NOTE This can occur where vertical and horizontal surfaces intersect.

3.1.9
decarburization
The removal of carbon from the surface and near surface of steel as a result of heating in a medium that reacts with the carbon.

NOTE Decarburization is usually present to a slight extent in steel forgings. Excessive decarburization can result in defective products.

3.1.10
die lubricant
A material sprayed, swabbed, or otherwise applied during forging to reduce friction and/or provide thermal insulation between the work piece and the dies.

NOTE Lubricants also facilitate release of the part from the dies and provide thermal insulation.

3.1.11
dies
die blocks
The metal blocks into which forging impressions are machined and from which forgings are produced.

3.1.12
dies, forging
Forms for the making of forgings; generally consist of a top and bottom die.

NOTE The simplest will form a completed forging in a single impression; the most complex, made up of several die inserts, may have a number of impressions for the progressive working of complicated shapes. Forging dies are usually in pairs, with part of the impression in one of the blocks and the balance of the impression in the other block.

3.1.13
discontinuities
Includes cracks, laps, folds, cold shuts, and flow-through, as well as internal defects such as inclusion, segregation, and porosity. Discontinuities may or may not be defects.

NOTE Internal discontinuities may be detected and evaluated using volumetric NDE techniques such as ultrasonic or radiographic examination.

3.1.14
flakes
Randomly oriented internal thermal cracks (shatter cracks) in steels resulting from critical combinations of stress and hydrogen content.

NOTE In a fracture surface, flakes appear as bright silvery areas; on an etched surface they appear as short discontinuous cracks.

3.1.15
flash
Metal in excess of that required to fill completely the blocking or finishing forging impression of a set of dies.

NOTE 1 Flash extends out from the body of the forging as a thin plate at the line where the dies meet and is subsequently removed by trimming. Because it cools faster than the body of the component during forging, flash can serve to restrict metal flow at the line where dies meet, thus ensuring complete filling of the impression.

NOTE 2 Also see **closed die forging**.

3.1.16
flow lines
Patterns in a forging resulting from the elongation of nonhomogeneous constituents in the grain structure of the material in the direction of working during forging; usually revealed by macroetching.

NOTE Also see **grain flow**.

3.1.17
fold
A forging defect caused by folding the metal back on its own surface during its flow in the die cavity.

NOTE Also see **lap**.

3.1.18
grain flow
Fiber-like lines appearing on polished and etched sections of forgings caused by orientation of the constituents of the metal in the direction of working during forging.

NOTE Proper grain flow produced by proper die design and metal working practices can improve the mechanical properties of forgings.

3.1.19
grain size
An expression that rates the number of grains per unit area of cross section as determined by metallographic examination.

3.1.20
heat
cast
A term used to identify the material produced from a single melting operation.

NOTE Different heats of the same material can vary in chemical composition within prescribed limits. Stock from a single heat will have a consistent analysis and more uniform properties.

3.1.21
heat treatment
A sequence of controlled heating and cooling operations applied to a solid metal to impart desired properties.

3.1.22
hot work ratio
forging reduction
The product of the hot work ratio for each hot working operation.

NOTE The forging reduction of the completed forging is the product of the reduction for all hot work operations including the original starting material reduction and each subsequent hot work operation. When the cross section of the starting material or forged part varies, the cross section resulting in the lowest calculated hot work ratio shall be used.

EXAMPLE For other than upset forging, the hot work ratio for a single hot work operation can be calculated using the following relationship:

$$\text{hot work ratio} = \frac{A_i}{A_f}: 1$$

where

A_f is the final cross-sectional area;

A_i is the initial cross-sectional area.

For upset forging, the hot work ratio for a single hot work operation can be calculated using the following relationship:

$$\text{upset hot work ratio} = \frac{A_f}{A_i}: 1 \text{ or } \frac{h_i}{h_f}: 1$$

where

A_f is the final cross-sectional area;

A_i is the initial cross-sectional area;

h_f is the final forging height;

h_i is the initial material height.

3.1.23
inclusions
Particles of nonmetallic compounds of metals and impurity elements that are present in ingots and are carried over in wrought products.

NOTE The shape and distribution of inclusions are changed by plastic deformation and contribute to directionality in metals.

3.1.24
ingot
A casting intended for subsequent rolling, forging, or extrusion.

3.1.25
ingotism
A defect common to almost all metal ingots in which metal crystals (dendrites) tend to grow at right angles to the walls of the mold and form planes of weakness at their junctions.

3.1.26
ladle refining
Practices used on molten steel in the ladle which are intended to remove impurities and undesirable chemical constituents from the molten metal.

3.1.27
lap
A surface irregularity appearing as a fissure or opening, caused by the folding over of hot metal, fins, or sharp corners, and by subsequent rolling or forging (but not welding) of these into the surface.

3.1.28
macroetch
A testing procedure for conditions such as porosity, inclusions, segregation, carburization, and flow lines from hot working.

NOTE Macroetching is done by applying a suitable etching solution to the polished metal surface so that the structure revealed by the action of the reagent can be observed visually.

3.1.29
melt practice
Procedure and equipment used to create a heat of metal. Includes the type of melting furnace used such as AOD, EAF, VAD, VAR, VOD, and VIM.

3.1.30
shuts (cold)
Faults produced in a forging by incorrect tool design or incorrect flow of steel that results in the formation of a crack in the forging surface.

3.1.31
starting material
The raw material used to produce a qualified forging. Starting materials may include billets, ingots, blooms, and blanks.

3.1.32
traceability
Traceability is the ability to verify the history, location, or application of an item by means of documented recorded identification.

3.1.33
wrought structure
Structure that contains no cast dendritic elements.

3.2 Acronyms and Abbreviations

AOD	argon oxygen decarburization
BOF	basic oxygen furnace
EAF	electric arc furnace
FSL	forging specification level
MPS	manufacturing procedure specification
NDE	nondestructive examination
UNS	unified numbering system
VAD	vacuum arc degassing
VAR	vacuum arc remelt
VOD	vacuum oxygen degassed
VIM	vacuum induction melting

4 Limits of Forging Qualifications

4.1 General

This standard gives the requirements for four FSLs. The FSLs are numbered in increasing levels of severity from 1 to 4 in order to reflect increasing technical, quality, and qualification criteria. The following subparagraphs describe the conditions which, when met, allow the forging to receive the appropriate FSL classification level.

4.2 FSL-1

4.2.1 A change in the type of furnace used in the starting material melt practice to basic oxygen furnace (BOF) melt practice requires requalification of the forging.

4.2.2 A change in material grade as shown in Table 1 from the forging that was previously qualified requires requalification of the forging.

4.2.3 A change in the as-forged weight range class as shown in Table 2 from the forging that was previously qualified requires requalification of the forging.

Table 1—Material Grades

Material Grade	Description	Examples
Grade 1	Carbon and low alloy carbon steels	ASTM A564, Grade F AISI 4130 [unified numbering system (UNS) G41300] AISI 8630, F22 (ASTM A182-F22)
Grade 2	Austenitic and martensitic stainless steels	410, F6NM, 316
Grade 3	Corrosion resistant alloys	718, 625

Table 2—As-forged Weight Range Classes

Specification Level	As-forged Weight (lb)							
	< 25	≥ 25 < 75	≥ 75 < 150	≥ 150 < 300	≥ 300 < 600	≥ 600 < 1200	≥ 1200 < 2400	≥ 2400
FSL-1	1A	1A	1A	1B	1B	1B	1C	1C
FSL-2	2A	2A	2B	2B	2C	2C	2D	2E
FSL-3	3A	3B	3C	3D	3E	3F	3G	3H
FSL-4 [a]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

[a] Weight range class is not applicable for FSL-4.

4.3 FSL-2

4.3.1 Qualification requirements specified for FSL-1 are required for FSL-2.

4.3.2 When ladle refining steps are used to produce the starting material for the qualification sample forging, the elimination of any ladle refining step from the starting material used for production forgings shall require requalification of the forging.

4.3.3 Requalification is required when the required hot work ratio (total forging reduction ratio) of the finished closed die forging exceeds that of the previously qualified forging.

4.3.4 A change in the minimum or maximum forging temperature from the forging that was previously qualified requires requalification of the forging.

4.4 FSL-3

4.4.1 Qualification requirements specified for FSL-1 and FSL-2 are required for FSL-3.

4.4.2 A change in the allowable minimum or maximum tolerance for any chemical element of the starting material greater than 15 % from the forging that was previously qualified requires requalification of the forging.

4.4.3 Any change to the melt practice used to produce the starting material from the forging that was previously qualified requires requalification of the forging.

4.4.4 Requalification is required when the minimum cleanliness of the finished closed die forging specified in ASTM E45 is less than the previously qualified forging.

4.4.5 A change in the basic type of forge equipment used (mechanical, press, hammer, etc.) from the forging that was previously qualified requires requalification of the forging.

4.4.6 An increase in the minimum acceptable yield strength or ultimate tensile strength of greater than 20 % required in the final product from the forging that was previously qualified requires requalification of the forging.

4.5 FSL-4

4.5.1 Qualification requirements for FSL-1, FSL-2, and FSL-3 are required for FSL-4.

4.5.2 A change in the actual mill used to supply the starting material from the forging that was previously qualified requires requalification of the forging.

4.5.3 A change in the specific material UNS designation from the forging that was previously qualified requires requalification of the forging.

4.5.4 Any change to the ladle refining practices used on the starting material from the forging that was previously qualified requires requalification of the forging.

4.5.5 A change in the immediate postforge thermal process used from the forging that was previously qualified requires requalification of the forging.

5 Forging Qualification Testing

5.1 Qualification Sample Product

A sample product shall be produced, tested, and evaluated by the forging supplier in order to establish qualification for a range of products described in Section 4. Sample products are to be in their completed forged form, with the addition of any specified rough machining and full heat treatment to establish final mechanical properties required of the finished product. Sample products used for qualification are to be produced in accordance with the requirements of Section 5 and Section 6.

5.2 Examination Procedure

5.2.1 Brinell and/or Rockwell hardness testing in accordance with ASTM E10, ASTM E18, or ASTM E110 shall be performed on the external surfaces of the sample to ensure the sample product is within the specified limits for the finished product. Results shall be documented.

5.2.2 Photographs of the qualification sample product shall be taken to document the surface finish, configuration, and general appearance.

5.2.3 Visual inspection of the forging shall be performed in accordance with MSS SP-55 for cracks, voids, blisters, laps, and other anomalies. Results shall be documented.

5.2.4 The forging shall be sectioned into four quadrants centered on the location of the heaviest cross section remaining in the finished machined product. Each quadrant shall be visually inspected and photographed for signs of cracks, voids, blisters, laps, etc. Care should be taken to evaluate abrupt changes in cross section and forged intersections. Results shall be documented.

5.2.5 The quadrant of the sample product with the greatest cross section gradient shall be liquid penetrant inspected in accordance with the requirements and acceptance criteria of API 6A, PSL-3. Results shall be documented.

5.2.6 One quadrant of the sample shall be macroetched in accordance with ASTM A604 or ASTM E381 to show the grain flow and internal structure. The surface of the sample closest to the centerline shall be chosen for etching. Photographs shall be taken of the etched section demonstrating the structure and grain flow with accompanying linear scale.

5.3 Mechanical Testing

5.3.1 Hardness testing shall be performed in accordance with ASTM E10, ASTM E18, or ASTM E110 on the sample traversing the entire cross section in two directions. Results shall be documented.

5.3.2 Tensile test specimens shall be removed from the sample and tested in accordance with ASTM A370 at the following locations:

a) at or near the surface of the forging,

b) at $^{1}/_{4}T$ thickness of the heaviest cross section as defined in API 6A,

c) at the location closest to the centerline of the heaviest cross section of the forging in the final heat treated condition.

In all locations, specimens shall be removed in two directions, in the direction of the grain flow identified 5.2.6 and in the direction oriented 90° from the grain flow.

5.3.3 Mechanical properties test results for elongation and reduction in area values in each area shall not vary from each other by more than 20 %. Results shall be documented.

5.3.4 Charpy (CVN) impact specimens shall be removed from one quadrant at the $^{1}/_{4}T$ and midsection areas and tested at 0 °F in accordance with ASTM A370. Orientation of the midsection specimens shall be 90° from the grain flow identified in 5.2.6. Results shall be documented.

5.4 Metallographic Examination

5.4.1 A metallographic sample shall be removed from the centerline of the heaviest cross section of the sample forging. This sample may be taken from the grip end of the centerline tensile specimen described in 5.3.

5.4.2 For Grade 1 and Grade 2 materials, steel cleanliness shall be determined in accordance with ASTM E45 as shown in Table 3. Photomicrographs shall be taken at 100X magnification showing average and worst-case field views. Results shall be documented.

5.4.3 Grain size shall be determined in accordance with ASTM E112 for the sample following etching with a suitable reagent. Photomicrographs of grain size shall be taken.

Table 3—Modified JK Inclusion Rating Limits

Inclusion Type	Thin	Heavy
Type A sulfide	1	1/2
Type B sulfide	1	1/2
Type C silicate	1	1/2
Type D oxide	1 1/2	1

5.5 Acceptance of the Qualification Sample Product

Samples failing to meet acceptance criteria shall be cause for reevaluation of the processes and procedures used and requalification is required.

5.6 Records of Qualification

The following records are required to document the qualification of the forging.

a) Starting Material, Grade—UNS number where applicable, heat number, material specification, supplier name, supplier mill, size, hot work ratio, cut weight, melt practice and ladle refinements, cleanliness, actual chemistry and minimum/maximum element tolerance, and incoming material inspection/evaluation method.

b) Forging Parameters—Hot work temperature range, description of each forging operation including product configuration at start and finish of each operation and hot work ratio for each step, and forge equipment used.

c) Postforging Parameters—Time, temperature, and media of cooling/bake-out, heat treatment specification and actual times and temperatures, cooling media, and heat treat equipment used.

d) Test Records—Records of the examination, mechanical testing, and metallographic evaluations, as described in 5.2, 5.3 and 5.4.

6 Production of Qualified Forgings

6.1 Qualification of Procurement Sources for Starting Material

6.1.1 Only melt sources (steel mills) that are approved by the forging supplier are to be used to supply starting material such as billet or ingot material. The forging supplier shall have a documented procedure, fully implemented, for qualifying starting material suppliers for each specific size and grade of starting material. The approval process shall be based on both a quality assurance and a technical evaluation. The approval process shall establish the methodology by which the starting material supplier will be evaluated on an ongoing basis to maintain their status as an approved supplier.

6.1.2 The maintenance of an acceptable quality program, such as an ISO registration, is not sufficient by itself to satisfy the requirements of 6.1.1. Documented evidence that a starting material supplier has a historical and ongoing technical capability of producing materials meeting this standard and who has proven, implemented procedures and capabilities in place to consistently produce acceptable product is a minimum requirement. Options for the technical approval of a starting material supplier include one or more of the following.

— Starting material receipt inspection that includes nondestructive examination (NDE), chemistry check, macroetch, etc. on a routine basis.

— Starting material first article cut up evaluation.

— Supplier experience over an extended period of time. Demonstration of acceptable experience shall include tests/inspections, quantity of material received, nonconformance analysis, etc.

6.1.3 The forging supplier is responsible for ensuring that a starting material supplier has implemented controls addressing the following for each size and grade of starting material ordered:

a) chemistry controls;

b) hydrogen controls;

c) melting practice controls;

d) pouring practice and ingot mold controls;

e) hot work practice controls (method of forging, amount of reduction, forging temperature, etc.);

f) cooling rate and method controls;

g) billet cropping controls;

h) starting material inspection and acceptance criteria (cleanliness requirements, limitations on porosity or inclusions, grain size, secondary phases, microstructure, macrostructure, etc., as applicable);

i) environmental exposure controls (e.g. mercury).

6.2 Material Specifications

6.2.1 The forging supplier shall document starting material requirements in the form of material specifications. Material specifications shall include as a minimum:

a) material grade, including element chemistry tolerances;

b) acceptable melt practices and ladle refinements;

c) acceptable forging reduction range;

d) acceptable cleanliness level range;

e) acceptable size, tolerances, and configuration of starting material;

f) acceptable inspection practices and criteria.

6.2.2 The forging supplier shall document acceptance of incoming starting material to the requirements of the material specification prior to use for production of forgings.

6.3 Design and Maintenance of Forging Dies and Equipment

6.3.1 Design

Design of forging dies and equipment used to produce forgings in accordance with this standard shall include documentation of those designs. This documentation shall include, as applicable:

a) design requirements,

b) assumptions,

c) analysis methods,

d) comparison with previous designs or operating history of similar products,

e) calculations,

f) manufacturing drawings and specifications,

g) design reviews and/or,

h) physical testing results (such as design validation testing).

Design documentation shall be reviewed by a qualified person other than the person who created the original design. Design documents and data, shall be maintained for five years after the date of last manufacture of that product.

6.3.2 Maintenance

Maintenance of forging dies and related equipment shall be conducted in accordance with documented procedures. Records of maintenance shall be kept.

6.3.3 Allowable Design Changes

Design changes shall be documented and reviewed by the forging supplier against the design documents to determine if the change is a substantive change.

All substantive design changes shall be documented, reviewed, and approved by a qualified person before their implementation and shall continue to meet the applicable requirements of this standard.

6.4 Manufacturing Procedure Specification (MPS)

The forging supplier shall prepare an MPS to include, as a minimum, allowable levels for all forging parameters including the process control variables listed in 6.5.1 and the heat treat parameters listed in 6.5.2.

6.5 Process Control Variables

6.5.1 General Variables

The following are general process control variables for the production of qualified forgings:

a) size of starting material, cut weight and tolerances;

b) evaluation process used for incoming material and for determining cropped length of starting material;

c) hydrogen flake-control method (bake-out, slow cool, etc.), if applicable;

d) hot working temperature range;

e) overall hot work ratio from ingot or continuous-cast bloom;

f) description of each forging operation, including general product configuration at the beginning and end of each different type of hot work or forging operation and hot work ratio for each step;

g) acceptable forging equipment for production.

6.5.2 Heat Treat Parameters

The following are heat treat parameters, as applicable:

a) furnace loading diagram and orientation of production parts;

b) normalizing temperature and time;

c) forging configuration and dimensions at time of heat treatment;

d) austenitizing temperature and time;

e) quenching medium and type of agitation (water/polymer, forced, horizontal; or vertical quench, ID/OD, etc.);

f) tempering temperature and time.

6.6 Forging Production

6.6.1 General

Forgings shall be produced by closed die forging according to the MPS specified in 6.4. The overall hot work ratio (as defined in 3.1) shall be sufficient to produce a wrought material structure throughout all sections of the forging as defined in 6.6.2. The overall hot work ratio from ingot or continuous-cast bloom to product shall be greater than or equal to 4 to 1 unless specifically agreed by the purchaser and the forging supplier.

As part of the MPS, forging steps shall be shown detailing initial and final dimensions during forging for each step. This will also include the heat or reheat temperature ranges required for each hot work reduction step by drawing and written documentation.

6.6.2 Wrought Material Structure

All forgings produced shall be of pressure vessel quality and shall have a wrought structure throughout. A fully-wrought structure is defined as follows.

a) Is free from piping and harmful segregation (the presence of which would indicate insufficient discard from the starting ingot).

b) Is free from burst, flakes, cracks, seams, laps, or other injurious defects detrimental to the end use of the part.

c) Is free from any open discontinuities (porosity, shrinkage, piping, cracks, etc.) when macroetched or viewed under a light microscope at 25X.

d) Has a homogenous microstructure in any given area. Some banding may be present in heavy sections. This is normal and will not be cause for rejection. The examination shall be documented and included in the forging qualification record.

e) Shows no evidence of macro segregation (ingotism).

6.7 Inspection, Quality Control, Marking, and Documentation

6.7.1 Calibration System

Inspection, measuring, and testing equipment used for acceptance shall be identified, inspected, calibrated, and adjusted at specific intervals in accordance with NCSL Z540 and this standard. Calibration standards shall be traceable

to the applicable national or international standards agency and shall be no less stringent than the requirements included herein. Inspection, measuring, and testing equipment shall be used only within the calibrated range.

Calibration intervals shall be established based on repeatability and degree of usage.

6.7.2 Furnace Calibration

Furnaces shall be calibrated in accordance with documented procedures. Records of furnace calibration shall be maintained.

6.7.3 Visual Inspection

All forgings shall be visually inspected in accordance with MSS SP-55 for cracks, voids, blisters, laps, and other anomalies. Results shall be documented.

6.7.4 Dimensional Inspection

Dimensional inspection shall be performed on products produced to this standard. Sampling shall be in accordance with ISO 2859-1, Level II, 1.5 AQL. The forging supplier shall specify and verify critical dimensions. Acceptance criteria for critical dimensions shall be as required by the forging supplier’s written specification.

6.7.5 Repair Welding

Repair welding is not permitted on forgings produced to this specification.

6.7.6 Marking

6.7.6.1 Each forging shall be marked with the following:

a) forging supplier's name or mark,

b) part number,

c) API 20C and FSL number,

d) traceability number (as defined in 6.7.6.2), and

e) heat number.

6.7.6.2 The traceability number shall refer to documentation containing the following as a minimum: heat number, heat treat lot number, MPS, material grade, specified material strength, date of manufacture, purchase order number, NDE and inspection results, and forging qualification record. At the option of the forging supplier, these items may be marked on the forging.

6.7.6.3 Procurement drawings or instructions shall identify where marking is appropriate. The above marking listed in 6.7.6.1 shall be applied using low-stress metal (dot or rounded V) stamps or vibration technique.

6.8 Traceability

Full traceability of forgings shall be maintained with respect to material, heat, MPS, heat treat loads, and:

a) forging qualification records shall be traceable to the MPS,

b) forgings produced to this specification shall be traceable to the applicable forging qualification record.

6.9 Record Retention

The forging supplier shall establish and maintain documented procedures to control the documents and data required by this standard. Records required by this standard shall be maintained for five years. Documents and data may be in any type of media (hard copy or electronic) and shall be:

— maintained to demonstrate conformance to specified requirements;

— legible;

— retained and readily retrievable;

— stored in an environment to prevent damage, deterioration or loss;

— available and auditable by the user/purchaser.

6.10 Handling, Storage, and Shipping

Forgings shall be packaged for storage or transit in accordance with the written specifications of the forging supplier.

Annex A
(informative)

API Monogram Program
Use of the API Monogram by Licensees

A.1 Scope

A.1.1 Applicability

This annex is only normative for product supplied bearing the API Monogram and manufactured at a facility licensed by API; for all other instances it is not applicable.

A.1.2 General

The API Monogram® is a registered certification mark owned by the American Petroleum Institute (API) and authorized for licensing by the API Board of Directors. Through the API Monogram Program, API licenses product manufacturers to apply the API Monogram to products which comply with product specifications and have been manufactured under a quality management system that meets the requirements of API Q1. API maintains a complete, searchable list of all Monogram licensees on the API Composite List website (www.api.org/compositelist).

The application of the API Monogram and license number on products constitutes a representation and warranty by the licensee to API and to purchasers of the products that, as of the date indicated, the products were manufactured under a quality management system conforming to the requirements of API Q1 and that the product conforms in every detail with the applicable standard(s) or product specification(s). API Monogram program licenses are issued only after an on-site audit has verified that an organization has implemented and continually maintained a quality management system that meets the requirements of API Q1 and that the resulting products satisfy the requirements of the applicable API product specification(s) and/or standard(s). Although any manufacturer may claim that its products meet API product requirements without monogramming them, only manufacturers with a license from API can apply the API Monogram to their products.

Together with the requirements of the API Monogram license agreement, this annex establishes the requirements for those organizations who wish to voluntarily obtain an API license to provide API monogrammed products that satisfy the requirements of the applicable API product specification(s) and/or standard(s) and API Monogram Program requirements.

For information on becoming an API Monogram Licensee, please contact API, Certification Programs, 1220 L Street, N. W., Washington, DC 20005 or call 202-682-8145 or by email at certification@api.org.

A.2 Normative References

In addition to the referenced standards listed earlier in this document, this annex references the following standard:

API Specification Q1, *Specification for Quality Management System Requirements for Manufacturing Organizations for the Petroleum and Natural Gas Industry*

For Licensees under the Monogram Program, the latest version of this document shall be used. The requirements identified therein are mandatory.

A.3 API Monogram Program: Licensee Responsibilities

A.3.1 Monogram Program Requirements

For all organizations desiring to acquire and maintain a license to use the API Monogram, conformance with the following shall be required at all times:

a) the quality management system requirements of API Q1;

b) the API Monogram Program requirements of API Q1, Annex A;

c) the requirements contained in the API product specification(s) to which the organization is licensed;

d) the requirements contained in the API Monogram Program License Agreement.

A.3.2 Control of the Application and Removal of the API Monogram

Each licensee shall control the application and removal of the API Monogram in accordance with the following:

a) Products that do not conform to API specified requirements shall not bear the API Monogram.

b) Each licensee shall develop and maintain an API Monogram marking procedure that documents the marking/ monogramming requirements specified by this annex and any applicable API product specification(s) and/or standard(s). The marking procedure shall:

   1) define the authority responsible for application and removal of the API Monogram and license number;

   2) define the method(s) used to apply the Monogram and license number;

   3) identify the location on the product where the API Monogram and license number are to be applied;

   4) require the application of the date of manufacture of the product in conjunction with the use of the API Monogram and license number;

   5) require that the date of manufacture, at a minimum, be two digits representing the month and two digits representing the year (e.g. 05-12 for May 2012) unless otherwise stipulated in the applicable API product specification(s) or standard(s); and

   6) define the application of all other required API product specification(s) and/or standard(s) marking requirements.

c) Only an API licensee shall apply the API Monogram and its designated license number to API monogrammable products.

d) The API Monogram and license number, when issued, are site-specific and subsequently the API Monogram shall only be applied at that site specific licensed facility location.

e) The API Monogram may be applied at any time appropriate during the production process but shall be removed in accordance with the licensee's API Monogram marking procedure if the product is subsequently found to be out of conformance with any of the requirements of the applicable API product specification(s) and/or standard(s) and API Monogram Program.

For certain manufacturing processes or types of products, alternative API Monogram marking procedures may be acceptable. Requirements for alternative API Monogram marking are detailed in the, *API Monogram Program*

Alternative Marking of Products License Agreement, available on the API Monogram Program website at http://www.api.org/alternative-marking.

A.3.3 Design and Design Documentation

Each licensee and/or applicant for licensing shall maintain current design documentation as identified in API Q1 for all of the applicable products that fall under the scope of each Monogram license. The design document information shall provide objective evidence that the product design meets the requirements of the applicable and most current API product specification(s) and/or standard(s). The design documentation shall be made available during API audits of the facility.

In specific instances, the exclusion of design activities is allowed under the Monogram Program, as detailed in Advisory # 6, available on API Monogram Program website at http://www.api.org/advisories.

A.3.4 Manufacturing Capability

The API Monogram Program is designed to identify facilities that have demonstrated the ability to manufacture equipment that conforms to API specifications and/or standards. API may refuse initial licensing or suspend current licensing based on a facility's level of manufacturing capability. If API determines that an additional review is warranted, API may perform additional audits (at the organization's expense) of any subcontractors to ensure their conformance with the requirements of the applicable API product specification(s) and/or standard(s).

A.3.5 Use of the API Monogram in Advertising

An API Monogram licensee shall not use the API Monogram and/or license number on letterheads, buildings or other structures, websites or in any advertising without an express statement of fact describing the scope of Licensee's authorization (license number and product specification). The Licensee should contact API for guidance on the use of the API Monogram other than on products.

A.4 Product Marking Requirements

A.4.1 General

These marking requirements shall apply only to those API Licensees wishing to mark applicable products in conjunction with the requirements of the API Monogram Program.

A.4.2 Product Specification Identification

Manufacturers shall mark products as specified by the applicable API specifications or standards. Marking shall include reference to the applicable API specification and/or standard. Unless otherwise specified, reference to the API specifications and/or standards shall be, as a minimum, “API [Document Number]” (e.g. API 6A, or API 600). Unless otherwise specified, when space allows, the marking may include use of “Spec” or “Std”, as applicable (e.g. API Spec 6A or API Std 600).

A.4.3 Units

Products shall be marked with units as specified in the API specification and/or standard. If not specified, equipment shall be marked with U.S. customary (USC) units. Use of dual units [USC units and metric (SI) units] may be acceptable, if such units are allowed by the applicable product specification and/or standard.

A.4.4 Nameplates

Nameplates, when applicable, shall be made of a corrosion-resistant material unless otherwise specified by the API specification and/or standard. Nameplate shall be located as specified by the API specification and/or standard. If the location is not specified, then the licensee shall develop and maintain a procedure detailing the location to which the nameplate shall be applied. Nameplates may be attached at any time during the manufacturing process.

The API Monogram and license number shall be marked on the nameplate, in addition to the other product marking requirements specified by the applicable product specification and/or standard.

A.4.5 License Number

The API Monogram license number shall not be used unless it is marked in conjunction with the API Monogram. The license number shall be used in close proximity to the API Monogram.

A.5 API Monogram Program: Nonconformance Reporting

API solicits information on products that are found to be nonconforming with API specified requirements, as well as field failures (or malfunctions), which are judged to be caused by either specification and/or standard deficiencies or nonconformities against API specified requirements. Customers are requested to report to API all problems with API monogrammed products. A nonconformance may be reported using the API Nonconformance Reporting System available at http://compositelist.api.org/ncr.aspx.

Bibliography

[1] ASTM A564 [5], *Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes*

[5] ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

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Online Orders: global.ihs.com

Information about API Publications, Programs and Services
is available on the web at www.api.org

Product No. G20C01