Designation: A 290/A 290M – 05

Standard Specification for Carbon and Alloy Steel Forgings for Rings for Reduction Gears[1]

This standard is issued under the fixed designation A 290/A 290M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This specification covers normalized and tempered, and quenched and tempered, carbon and alloy steel forged or rolled rings for reduction gears.

1.2 Several grades and classes of steel are covered as follows:

1.2.1 Grade 1, Classes A and B, and Grade 2, Classes C and D, are carbon steel.

1.2.2 Grade 3, Classes E and F, Grade 4, Classes G, H, I, J, K and L, Grade 5, Classes M and P, and Grade 6, Class T, are alloy steel.

1.2.3 All grades and classes are considered weldable under proper conditions. Welding techniques are of fundamental importance and it is pre-supposed that welding procedure and inspection will be in accordance with proper methods for the class of material used.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 275/A275M Test Method for Magnetic Particle Examination of Steel Forgings

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products

A 388/A388M Practice for Ultrasonic Examination of Heavy Steel Forgings

A 788 Specification for Steel Forgings, General Requirements

3. Terminology

3.1 *Definitions*—Definitions of the terms used may be found in Specification A 788.

4. Ordering Information and General Requirements

4.1 In addition to the ordering information required by Specification A 788, the purchaser shall specify in the inquiry, contract, and order the grade and class desired and the supplementary requirements, if any, which should apply.

4.2 Material supplied to this specification shall conform to the requirements of Specification A 788, which outlines additional ordering information, manufacturing requirements, testing and retesting methods and procedures, marking, certification, product analysis variations, and additional supplementary requirements.

5. Materials and Manufacture

5.1 *Melting Process*:

5.1.1 The steel shall be produced by any of the melting requirements in Specification A 788, which may be supplemented by Supplementary Requirement S6, Vacuum Degassing.

5.2 *Discard*—Sufficient discard shall be taken from each ingot to secure freedom from piping and undue segregation.

5.3 *Forging Process*—The forgings shall receive their hot mechanical work in accordance with the requirements of Specification A 788.

5.4 *Heat Treatment*:

5.4.1 *Cooling Prior to Heat Treatment*—After forging and before reheating for heat treatment, the forgings shall be allowed to cool in a manner to prevent injury, to accomplish transformation, and prevent flakes.

5.4.2 Heat treatment shall consist of normalizing and tempering for Grade 1 classes A and B and quenching and tempering for all other grades and classes.

5.4.2.1 *Normalizing*—A furnace charge thus treated is termed a normalizing charge.

5.4.2.2 *Quenching*—The forgings shall be completely austenitized and then quenched in a suitable medium. A group thus treated is termed a quenching charge.

5.4.2.3 *Tempering*—A furnace charge thus treated is termed a tempering charge. Minimum tempering temperatures shall be as follows:

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard.**

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Grade and Class	Minimum Tempering Temperature °F	[°C]
Grade 1 Classes A and B	1200	[650])
Grade 2 Classes C & D, E, F, G, H, M, P	1100	[595])
Grade 3 Classes E & F	1100	[595]
Grade 4 Classes G & H	1100	[595]
Grade 5 Classes M & P	1100	[595]
Grade 4 Classes I, J, K & L	1050	[565]
Grade 6 Class T	1000	[540]

5.5 *Machining*:

5.5.1 Rough machining before heat treatment for mechanical properties may be performed at the option of the producer.

5.5.2 The forgings shall conform to the sizes and shapes specified by the purchaser.

6. Chemical Composition

6.1 *Composition*—The steel shall conform to the requirements for chemical composition prescribed in Table 1. Alternative compositions may be agreed upon in accordance with Supplementary Requirement S1.1.

6.1.1 *Heat Analysis*—The heat analysis obtained from sampling in accordance with Specification A 788 shall comply with Table 1.

6.1.2 *Product Analysis*—An analysis may be made by the purchaser from a forging representing each heat. Samples for analysis may be taken from the forging or from a full-size prolongation at any point midway between the inner and outer surfaces of the ring or samples may be taken from the test specimen. The chemical composition thus determined shall not vary from the requirements prescribed in Table 1 by more than the amounts prescribed in Specification A 788.

7. Mechanical Properties

7.1 *Tension and Impact Test Requirements*—The requirements for tensile and impact properties shall be as prescribed in Table 2.

7.1.1 *Number, Location, and Orientation of Test Specimens*—On classes requiring tension tests, two tension test specimens and two sets of impact tests shall be taken 180° apart from a full-size prolongation left on one end of each individual forging or both ends of each multiple forging. The test specimens shall be in a tangential direction at midwall of the ring as close as practical to the end of the rough-machined forging face.

7.1.2 *Test Method*—Full-size tension and Charpy V-notch impact tests shall be conducted in accordance with Test Methods and Definitions A 370.

7.2 *Brinell Hardness*—Forgings shall be within the hardness ranges specified in Table 2. The permissible variation of hardness in any forging shall not exceed 30 numbers for all classes except Classes K and L which shall be 40 numbers.

7.2.1 *Number and Location of Tests*—Brinell hardness tests shall be taken on each forging, regardless of weight or class, after final heat treatment and final machining to dimensions shown on the drawing submitted with the purchase order. Each test shall be approximately ¼ of the radial thickness from the outside diameter. The number and location of the hardness tests follows:

Outside Diameter, in. [cm]	Number of Tests
To 40 [100]	1 on each end 180° apart
40 to 80 [100 to 200]	2 on each end 180° apart
80 to 120 [200 to 300]	3 on each end 120° apart
Over 120 [300]	4 on each end 90° apart

7.2.2 *Test Method*—Tests shall be made in accordance with Test Methods and Definitions A 370.

8. Certification

8.1 The certification requirements of Specification A 788 shall apply together with a manufacturer's certification that the material was manufactured and tested in accordance with this specification.

9. Product Marking

9.1 In addition to the marking requirements of Specification A 788, identification marks shall be legibly stamped on each forging. The purchaser may indicate the desired location of such identification marks.

10. Rejection

10.1 Unless otherwise specified, any rejection based on tests made in accordance with Section 6 shall be reported to the manufacturer within 60 working days from the receipt of samples by the purchaser.

11. Keywords

11.1 alloy steel forgings; carbon steel forgings; gear rings; heat-treated; reduction gears

TABLE 1 Chemical Requirements

Element	Composition, %					
	Grade 1 Classes A and B	Grade 2 Classes C and D	Grade 3 Classes E and F	Grade 4 Classes G, H, I, J, K, and L	Grade 5 Classes M and P	Grade 6 Class T
Carbon	0.35–0.50	0.40–0.50	0.35–0.45	0.35–0.45	0.38–0.45	0.25–0.39
Manganese	0.60–0.90	0.60–0.90	0.70–1.00	0.60–0.90	0.40–0.70	0.20–0.60
Phosphorus, max	0.040	0.040	0.040	0.040	0.040	0.015
Sulfur, max	0.040	0.040	0.040	0.040	0.040	0.015
Silicon[A], max	0.35	0.35	0.35	0.35	0.40	0.35
Nickel	0.30 max	0.30 max	0.50 max	1.65–2.00	0.30 max	3.25–4.00
Chromium	0.25 max	0.25 max	0.80–1.15	0.60–0.90	1.40–1.80	1.25–1.75
Molybdenum	0.10 max	0.10 max	0.15–0.25	0.20–0.50	0.30–0.45	0.30–0.70
Vanadium, max	0.06	0.06	0.06	0.10	0.03	0.05–0.15
Copper, max	0.35	0.35	0.35	0.35	0.35	0.35
Aluminum	. . .	. . .	. . .	. . .	0.85–1.30	. . .

[A] When vacuum carbon deoxidation is used, silicon maximum shall be 0.10 %.

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TABLE 2 Mechanical Requirements

Grade	Class	Tensile Strength, min, ksi [MPa]	Yield Strength, 0.2 % Offset, min, ksi [MPa]	Elongation in 2 in. or 50 mm, min, %	Reduction in Area, min, %	Brinell Hardness Range	Charpy V-Notch at 70 to 80°F [21 to 27°C], ft·lbf [J]
1	A	80 [550]	45 [310]	22	45	163 to 202	10 [14]
1	B	...	...	...	...	163 to 202	...
2	C	95 [655]	65 [450]	20	40	197 to 241	10 [14]
2	D	...	...	...	...	197 to 241	...
3	E	105 [725]	75 [515]	20	45	223 to 269	30 [41]
3	F	...	...	...	...	223 to 269	...
4	G	125 [860]	100 [690]	15	42	262 to 311	30 [41]
4	H	...	...	...	...	262 to 311	...
4	I	145 [1000]	120 [825]	14	40	302 to 352	25 [34]
4	J	...	...	...	...	302 to 352	...
4	K	170 [1175]	145 [1000]	10	35	341 to 401	20 [27]
4	L	...	...	...	...	341 to 401	...
5	M	120 [825]	85 [585]	15	40	255 to 302	8 [11]
5	P	...	...	...	...	255 to 302	...
6	T	170 [1175]	140 [960]	10	30	352 to 401	25 [34]

SUPPLEMENTARY REQUIREMENTS

These requirements shall not be considered unless specified in the order in which event the supplementary tests specified in S1 to S3 shall be made at the mill, unless otherwise agreed upon, and witnessed by the purchaser's inspector before shipment of the material.

S1. Chemical Requirements

S1.1 Alternate compositions may be agreed upon between the manufacturer and the purchaser.

S2. Machining

S2.1 Rough machining prior to heat treatment for mechanical properties may be specified by the purchaser.

S3. Nondestructive Testing

S3.1 Magnetic particle tests may be specified by agreement between manufacturer and purchaser and if required should be in accordance with Test Method A 275/A 275M.

S3.2 Ultrasonic tests may be specified by agreement between manufacturer and purchaser and if required should be in accordance with Practice A 388/A 388M.

S4. Restricted Chemistry—Vanadium

S4.1 The vanadium content shall be 0.03 % maximum for Classes A, B, C, and D when determined in accordance with S1.

S5. Restricted Chemistry—Phosphorus

S5.1 Phosphorus shall not exceed 0.015 %, and sulfur shall not exceed 0.018 % for all Classes when determined in accordance with 6.1.1 or at the locations specified in 6.1.2.

S6. Vacuum Degassing

S6.1 The molten steel shall be vacuum treated, prior to or during pouring of the ingot to remove objectionable gases, particularly hydrogen.

SUMMARY OF CHANGES

Committee A01 has identified the location of several changes to this standard since the last issue (A 290 – 02) that may impact its use.

(1) Converted to Dual format.

(2) Added several sections which are already covered in the general requirements of Specification A 788

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