Designation: A391/A391M – 21

Standard Specification for Grade 80 Alloy Steel Chain[1]

This standard is issued under the fixed designation A391/A391M; 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 Grade 80 heat-treated alloy steel chain for such applications as slings, lifting assemblies, and load binding. For overhead lifting applications, only alloy chain should be used.

1.2 The chain grade is based on the nominal stress in the link at the design breaking force strength. It is calculated by taking the minimum breaking force load and dividing by two times the nominal cross-sectional area of the link.

1.3 The values stated in either SI units or in other units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.3.1 *Metric Units*—Grade = 1/10 of the minimum breaking force in kilonewtons divided by two times the nominal cross-sectional area in square millimeters.
= (MBF)/(0.005)(π)(d)(d)

1.3.2 *English Units*—Grade = 0.000689 of the minimum breaking force in pounds divided by two times the nominal cross-sectional area in square inches.
= (0.000689)(MBF)/(0.5)(π)(d)(d)

1.3.3 MBF = minimum breaking force (lb or kN); d = chain diameter (in. or mm).

NOTE 1—The above formulas are for round diameter links only. If different cross sections are used, the actual cross section of the link would need to be calculated and used.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A29/A29M Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought

A751 Test Methods and Practices for Chemical Analysis of Steel Products

A941 Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *breaking force, minimum, n*—minimum force in pounds or newtons at which the chain, during manufacture, has been found by testing to break when a constantly increasing force is applied in direct tension.

3.1.1.1 *Discussion*—This test is a manufacturer's attribute acceptance test and shall not be used as criteria for service.

3.1.2 *date code, n*—series of letters, numbers, or both, embossed on the chain which enables its manufacturing history to be traced.

3.1.3 *lot, n*—for the purpose of acceptance testing, a lot shall consist of 3000 ft [1000 m], or fraction thereof, of the same grade and size chain. If a continuous length of chain exceeds 3000 ft [1000 m], it shall also be considered a lot.

3.1.4 *proof test, n*—quality control tensile test applied to chain for the purpose of verifying weld and material quality.

3.1.4.1 *Discussion*—It is the minimum force in pounds or newtons which the chain has withstood at the time it left the producer, under a test in which a constantly increasing force has been applied in direct tension to a straight length of chain. Proof test loads are a manufacturing integrity test and shall not be used as criteria for service or design purposes.

3.1.5 *traceability code, n*—series of letters, numbers, or both, embossed on the chain which enables its manufacturing history, including the identity of the steel heat, to be traced.

[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.27 on Steel Chain.

Current edition approved Jan. 1, 2021. Published January 2021. Originally approved in 1955. Last previous edition approved in 2012 as A391/A391M – 07 (2012). DOI: 10.1520/A0391_A0391M-21.

[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**

3.1.6 *working load limit (WLL), n*—maximum combined static and dynamic load in pounds or kilograms that shall be applied in direct tension to an undamaged straight length of chain.

4. Ordering Information

4.1 It shall be the responsibility of the purchaser to specify all requirements that are necessary for material ordered under this specification. Such requirements to be considered include, but are not limited to, the following:

4.1.1 Product to conform to Specification A391 or A391M and year of issue,

4.1.2 Nominal size of chain in in. [mm],

4.1.3 Quantity of chain in ft [m],

4.1.4 Length of each piece, if required,

4.1.5 Finish, if required,

4.1.6 Certification of test(s), if required, and

4.1.7 Acceptance of inspection by purchaser, if required.

5. Manufacturing

5.1 *Melting Process*—The alloy steel shall be made to a fully-killed fine austenitic grain process.

5.2 *Welding Process*—Alloy steel chain may be made by the electric welding or gas welding process.

5.3 *Heat Treatment*—After welding, alloy steel chain shall be heat treated before applying the proof test. Heat treatment shall include quenching and tempering as defined by Terminology A941.

6. Material Requirements

6.1 *Heat Analysis*—The selection and amounts of the alloying elements in the steel are left to the judgment of the individual chain manufacturer provided the steel meets the following criteria: Carbon: 0.35 % max.; Phosphorous: 0.025 % max.; Sulfur: 0.025 % max. Nickel must be present in an alloying amount (0.40 % min); and at least one of the following elements must be present in an alloying amount: Chromium (0.40 % min) or Molybdenum (0.15 % min).

6.2 *Product Analysis*—The steel used may be analyzed by the purchaser and shall conform to the requirements of 6.1 subject to the product analysis tolerances specified in Specification A29/A29M. Test samples may be taken from rods, bars, or finished chain. Samples for analysis shall be so taken as to represent the full cross section of the specimen.

6.3 Test Methods and Practices A751 shall be used for referee purposes.

7. Mechanical Requirements

7.1 *Proof Test*—Every link of chain shall be tested to at least the proof load prescribed in Table 1 for the appropriate size chain. When so tested it shall withstand these loads without loss of chain integrity. Links or chain segments not withstanding the proof test load shall be removed from the chain.

7.2 *Breaking Force*—The breaking force test specimen shall consist of a length from the lot containing at least the number of links in Table 2. All chain shall be in the quenched and tempered condition before the breaking force is measured.

7.2.1 Fixtures for securing chain in a testing machine shall be properly designed to support securely the shoulder of the link (see Note 2). The opening in the fixture shall not be more than 125 % of the stock diameter being tested. Links engaged in the testing fixture shall not be considered part of the test specimen.

NOTE 2—"U" bolts of the same or larger diameter and the same or greater strength may be used to secure the chain to the jaws of the testing machine.

7.2.2 Test specimens shall meet or exceed the minimum breaking force values given in Table 1 for the appropriate size chain.

7.3 *Elongation:*

7.3.1 All chain must be in the quenched and tempered condition before the elongation is measured.

7.3.2 The elongation test specimen shall consist of a length from the lot containing at least the number of links in Table 2.

7.3.3 A positive load not exceeding 10 % of the proof test shall be applied for determining the original gauge length ($L\{0\}$).

7.3.4 The elongation shall be based on the total extension at fracture. This is expressed as a percentage of the change in length (ΔL) divided by the original gauge length ($L\{0\}$). The elongation may be determined by the equation below or by autographic recorder or side scale.

$$\text{Elongation}\ (\%) = \{\Delta L/L\{0\}\} \times 100$$

TABLE 1 Grade 80 Alloy Chain Mechanical and Dimensional Requirements

Nominal Chain Size		Material Diameter		Working Load Limit, max		Proof Test,[A] min		Minimum Breaking Force[A]		Inside Length, max		Inside Width, min to max	
in.	mm	in.	mm	lb	kg	lb	kN	lb	kN	in.	mm	in.	mm
7/32	5.5	0.217	5.5	2 100	970	4 200	19.0	8 400	38.0	0.69	17.6	0.281 to 0.325	7.14 to 8.25
9/32	7.0	0.276	7.0	3 500	1 570	7 000	30.8	14 000	61.6	0.90	22.9	0.375 to 0.430	9.53 to 10.92
5/16	8.0	0.315	8.0	4 500	2 000	9 000	40.3	18 000	80.6	1.04	26.4	0.430 to 0.500	10.92 to 12.70
3/8	10.0	0.394	10.0	7 100	3 200	14 200	63.0	28 400	126.0	1.26	32.0	0.512 to 0.600	13.00 to 15.20
1/2	13.0	0.512	13.0	12 000	5 400	24 000	107.0	48 000	214.0	1.64	41.6	0.688 to 0.768	17.43 to 19.50
5/8	16.0	0.630	16.0	18 100	8 200	36 200	161.0	72 400	322.0	2.02	51.2	0.812 to 0.945	20.63 to 24.00
3/4	20.0	0.787	20.0	28 300	12 800	56 600	252.0	113 200	504.0	2.52	64.0	0.984 to 1.180	25.00 to 30.00
7/8	22.0	0.866	22.0	34 200	15 500	68 400	305.0	136 800	608.0	2.77	70.4	1.080 to 1.300	27.50 to 33.00
1	26.0	1.024	26.0	47 700	21 600	95 400	425.0	190 800	850.0	3.28	83.2	1.280 to 1.540	32.50 to 39.00
1 1/4	32.0	1.260	32.0	72 300	32 800	144 600	644.0	289 200	1288.0	4.03	102.4	1.580 to 1.890	40.00 to 48.00

[A] The proof test and minimum breaking force loads *shall not* be used as criteria for service or design purposes. (See Section 3.)