Specification for Mooring Chain

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CONTENTS

Page

1 SCOPE 1

2 REFERENCES 1

3 BAR STOCK REQUIREMENTS AND TESTS 1

4 CHAIN REQUIREMENTS AND TESTS 3

5 KENTER LINK REQUIREMENTS AND TESTS 8

Figures
1—Tensile Test Specimen 2
2—Orientation of Charpy V-Notch Impact Test Specimens 2
3—Basic Link and Stud Weldment 4
4—Kenter Link Critical Dimensions 9
5—Critical Shapes to Be Mated With API Kenter Link 11

Tables
1—Chemical Composition Ladle Analysis 1
2—Mechanical Properties 2
3—Dimensional Tolerance of Bar Stock 2
4—Frequency of Tests 3
5—Dimensions and Tolerances 4
6—Mooring Chain Proof and Break Tests, Length Over Five Links, and Approximate Weight (Customary Units) 5
7—Mooring Chain Proof and Break Tests, Length Over Five Links, and Approximate Weight (SI Units) 6
8—Kenter Link Dimensions and Tolerances 10

Specification for Mooring Chain

1 Scope

This specification covers flash-welded chain and forged kenter connecting links used for mooring of offshore floating vessels such as drilling vessels, pipe lay barges, derrick barges, and storage tankers.

2 References

The most recent editions or revisions of the following standards are referenced in this publication:

ASTM[1]

A 370	*Mechanical Testing of Steel Products*
E 309-95	*Eddy-Current Examination of Steel Tubular Products Using Magnetic Saturation*
E 709	*Magnetic Particle Examination*
E 1444	*Magnetic Particle Inspection*
DNV	*Certification Notes 2.6,* July 1985
ISO	R286-1962 Code H11, h11

3 Bar Stock Requirements and Tests

3.1 STEEL MAKING PROCESS

The steel used for the manufacture of chain shall be made by the open hearth, basic oxygen, or electric furnace process.

3.2 CHEMICAL COMPOSITION

All material shall be of fine grain quality. The chemical composition shall be determined at the steel mill on samples taken from each ladle of each heat and shall comply with the composition shown in Table 1. A copy of the mill sheet listing the chemical composition of each heat shall be provided to the owner's representative. If the material fails to satisfy the chemical composition requirements in Table 1, the material shall be rejected.

3.3 MECHANICAL PROPERTIES

The bar stock used in the manufacture of chain furnished to this specification shall possess the mechanical properties shown in Table 2. These properties shall be determined at either the steel mill or the manufacturing facility in the manner described below. Results shall be certified by a recognized testing agency and submitted to the owner's representative.

3.4 TENSILE TESTS

One tensile test shall be made on each heat of steel.

[1]American Society for Testing and Materials, 100 Bar Harbor Drive, West Conshohocken, Pennsylvania 19428.

Table 1—Chemical Composition Ladle Analysis

Element	Percent Minimum Maximum
Carbon, C	0.33
Silicon, Si	0.20–0.35
Manganese, Mn	1.90
Phosphorus, P	0.04
Sulphur, S	0.04
Nitrogen, N	0.015
Chromium, Cr	0.25
Copper, Cu	0.35
Columbium, Cb (Niobium, Nb)[a]	0.05
Nickel, Ni	0.40
Vanadium, V[a]	0.10
Aluminum, Al[a]	0.065
Molybdenum, Mo	0.08

[a]To obtain fine grain steel, at least one of these grain refining elements in sufficient amount(s) must be present to meet the fine grain practices per 3.2.

Note: When more than one test specimen for each heat is required to be in compliance with classification-society rules, the frequency of removing test specimens is to be based on classification rules.

Tensile properties shall be determined on a longitudinal specimen conforming to the requirements of 3.5. The results of the test shall meet or exceed the minimum requirements listed in Table 2. If the original test fails to meet the requirements in Table 2 but are within 2000 pounds per square inch (14 megapascals) of the required tensile strength, or within 2 percent of the required elongation, a retest of another specimen selected from the same heat is permissible. If the second test fails to meet the requirements of Table 2 the material shall be rejected.

3.5 TENSILE TEST SPECIMENS

The tensile specimen shall be taken from bar stock which has been subjected to the same heat treatment as that specified for the finished chain. Tensile test specimens may be either full bar diameter or machined specimens as shown in Figure 1, at the option of the manufacturer. For test specimens with diameters smaller than the full bar diameter, the position of the test specimen relative to the bar cross section shall be selected so that the specimen is representative of the average properties of the bar.

3.6 IMPACT TESTS

Three impact tests shall be made on each heat of steel.

Note: When more than three test specimens for each heat are required to be in compliance with classification-society rules, the frequency of removing test specimens is to be based on classification rules.

Impact properties shall be determined on specimens conforming to the requirements of 3.7. The average results of the three tests shall meet or exceed the minimum requirements

Table 2—Mechanical Properties

Tested Properties	Requirements
Ultimate strength, minimum	93,000 pounds per square inch (641 megapascals)
Elongation, minimum[a]	17 percent
Reduction in area, minimum	40 percent
Impact, average	
Bar stock and unwelded portion of link	43 foot-pounds @ 32°F (58 Joules @ 0°C)
Flash weld zone	36 foot-pounds @ 32°F (49 Joules @ 0°C)
Impact, average for low-temperature application	
Unwelded portion of link	29.5 foot-pounds @ 5°F (40 Joules @ -15°C)
Flash weld zone	26.5 foot-pounds @ 5°F (36 Joules @ -15°C)

[a]The minimum elongation of 17% is based on a specimen having gauge length equal to five times the diameter of the specimen. For specimens having other gauge lengths, the equivalent elongation may be calculated by the following formula:

$$n = 2E\left(\frac{\sqrt{A}}{L}\right)^{0.4}$$

Where:

n = the equivalent minimum elongation, %.
A = the actual cross-sectional area of the specimen, inch^2 (millimeter^2).
L = the actual gauge length, inch (millimeter).
E = the specified minimum percentage elongation for specimens having a gauge length of five times the specimen diameter, %.

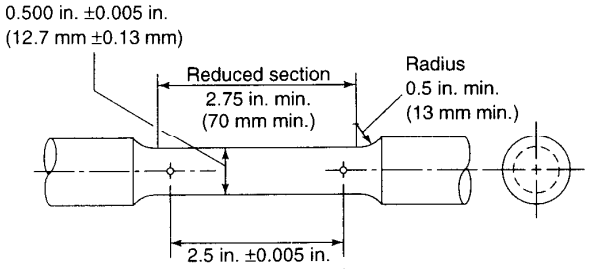
listed in Table 2. If the average fails to meet the minimum requirement by an amount not exceeding 15 percent, three additional specimens from the same bar stock may be tested and the results added to those previously obtained to form a new average. If the new average fails to meet the requirements of Table 2, the material shall be rejected. No individual Charpy values shall be less than 75 percent of the average minimum requirement.

3.7 IMPACT TEST SPECIMENS

Impact test specimens shall be taken from bar stock which has been subjected to the same heat treatment as that specified for the finished chain. Impact test specimens shall be Charpy V-notch as described in ASTM A 370. General orientation of the specimens shall be as shown in Figure 2.

3.8 DIMENSIONAL TOLERANCE AND REQUIRED INSPECTION

The diameter tolerance on bar stock used in the manufacture of chain furnished to this specification shall be as shown in Table 3. One hundred percent of the bar stock shall be examined by magnetic particle inspection per ASTM E 709 and ASTM E 1444 or eddy-current inspection, ASTM E 309.



Gauge length for measuring elongation after fracture

Note: The gauge length and fillets shall be as shown, but the ends may be of any shape to fit the holders of the testing machine in such a way that the load shall be axial. The reduced section may have a gradual taper from the ends toward the center, with the ends not more than 0.005 inch larger in diameter than the center.

Figure 1—Tensile Test Specimen

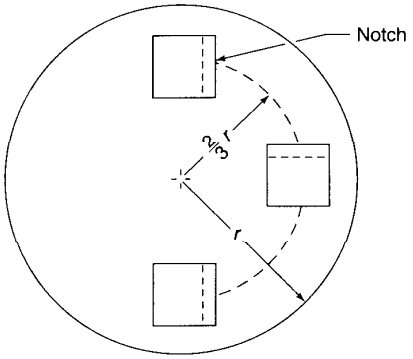


Figure 2—Orientation of Charpy V-Notch Impact Test Specimens

Table 3—Dimensional Tolerance of Bar Stock

Nominal Size of Bar Stock (inches)	Tolerance (inches)	Nominal Size of Bar Stock (millimeters)	Tolerance (millimeters)	Maximum Depth of Longitudinal Defects (millimeters)
Up to 1 3/8	+1/32 –0	Up to 34	+1.2 –0	0.40
1 1/2 to 2	+1/16 –0	34 to 50	+1.6 –0	0.50
2 1/8 to 3 1/8	+3/32 –0	51 to 80	+2.0 –0	0.80
3 1/4 to 4	+3/32 –0	81 to 100	+2.6 –0	1.00
4 1/8 to 4 3/4	+1/8 –0	101 to 120	+3.0 –0	1.20
4 7/8 to 6 3/8	+5/32 –0	121 to 160	+4.0 –0	1% of *d*
6 1/2 to 7 7/8	+3/16 –0	161 to 200	+5.0 –0	1% of *d*

4 Chain Requirements and Tests

4.1 IDENTIFICATION OF TEST LINKS

Chain shall be manufactured in continuous lengths. For identification during manufacture, each length of chain should be marked with a metal band strapped around the stud of the second link from either end of the total length. The length number shall be stamped on the metal band. No number should be duplicated.

4.2 TEST SPECIMEN

During manufacture, a specimen consisting of at least four links shall be taken from the chain in accordance with Table 4 to provide the test specimen for break tests and mechanical property measurements. After removal of the specimen from the chain, the specimen shall be identified with a metal band placed around the stud of one of the links. The identification shall include the order number, the chain length number, and the test specimen number (for example, 2-2-3 could denote the second order, the second length of chain, and the third specimen removed from the second length of chain). A metal band with the same marking shall be placed around the stud of the last link in the continuous portion of the chain to denote the location where the specimen was removed. After removal of the specimen, manufacture of the chain shall resume with a new common link being inserted into the last link of the continuous chain length previously constructed.

4.3 MARKING FOR PERMANENT IDENTIFICATION

The common links marked with metal bands shall be marked for permanent identification using the same numbering system described above. Markings shall be on the stud and may be accomplished by a forging stamp or weld metal deposit.

4.4 CHAIN STUD

The studs shall be drop-forged and shall not have lugs or protrusions on either end. After the stud is inserted into the oval link, unless otherwise agreed, it shall be circumferentially welded in place on the end opposite the flash weld. The size of the fillet weld will comply with the data shown in Figure 3 and Table 5. Only low-hydrogen electrodes shall be used, and the welds are to have good penetration with a maximum undercut not to exceed 1/32 inch (1 millimeter). All welding shall be performed prior to the final heat treatment. Studs and chain shall meet the same material chemical specification per Table 1.

4.5 HEAT TREATMENT OF COMPLETED CHAIN

The chain shall be normalized, normalized and tempered, or quenched and tempered to produce a fine grain structure throughout the link's weld and fusion zone. All chain is to be heat-treated by continuous processing; batch heat treatment is not permitted. Heat treatment shall be performed after all welding has been completed and prior to testing and inspection. The test links which were removed during manufacture for break tests and mechanical property tests shall be securely attached to the completed chain for heat treatment.

Table 4—Frequency of Tests

Nominal Chain Size		Maximum Specified Length to Obtain Samples	
(inches)	(millimeters)	(feet)	(meters)
Minimum–1 7/8	Minimum–48	300	91
2–2 3/8	50–60	360	110
2 1/2–2 3/8	64–73	430	131
3–3 3/8	76–85	500	152
3 1/2–3 7/8	87–98	575	175
4–4 3/8	102–111	650	198
4 1/2–4 7/8	114–124	730	222
5–5 3/8	127–137	820	250
5 1/2–5 7/8	140–149	900	274
6–6 3/8	152–162	975	297
6 1/2–6 7/8	165–175	1055	322
7–7 3/8	178–187	1130	344

Notes: If an order or a fraction of an order is less than the specified length, that length shall be subject to all tests required for a full length.
The above table indicates the maximum allowable interval for selecting samples. In the event that compliance with classification society rules (which specify more frequent sampling) is also required, the frequency of removing samples is to be based on classification rules.

4.6 CLEANING

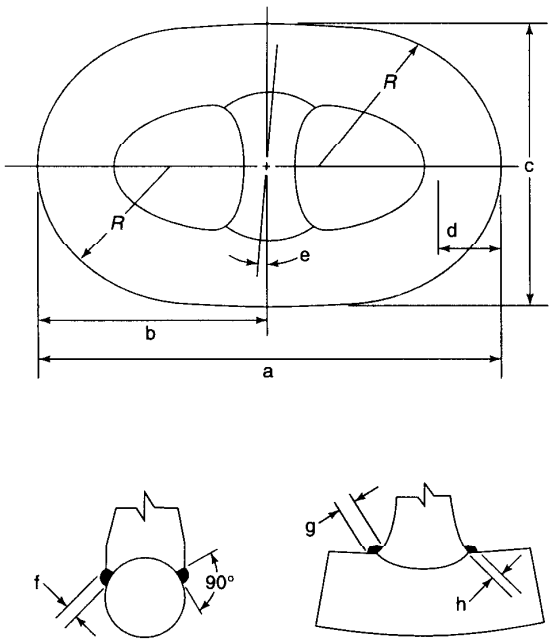
The chain shall be cleaned by shot blasting, sand blasting, or other suitable means of preparing the link surfaces for inspection.

4.7 TESTING AND INSPECTION OF CHAIN AFTER HEAT TREATMENT

The following tests and inspection shall be performed:

a. Break test.
b. Proof test.
c. Length over five links.
d. Inspection of flash weld.
e. Inspection for surface defects.
f. Link dimension and measurements.
g. Tests to determine mechanical properties.

All proof tests and breaking strength tests shall be conducted in a well-lighted area in the presence of the purchaser's inspectors. Following proof testing, a detailed inspection of the chain shall be made by the purchaser's inspector(s). The chain shall be suspended 3 feet to 4 feet (approximately 1 meter) above the floor to permit careful inspection from all sides. The chain shall be free of paint or other coating which would tend to conceal defects during the testing and inspection.



Note: See Table 5 for dimensions and tolerances.

Figure 3—Basic Link and Stud Weldment

Table 5—Dimensions and Tolerances (See Figure 3)

Dimension Designation	Nominal Dimension	Tolerance	
		Minus	Plus
a	6*d*	0.0*d*	0.15*d*
b	3*d*	0.1*d*	0.1*d*
c	3.6*d*	0.09*d*	0.09*d*
e	0.0°	4°	4°
f	0.10*d*	0.01*d*	
g	0.20*d*	0.02*d*	
h	0.09*d*	0.01*d*	

Note: *d* = nominal diameter of barstock.

4.8 PURCHASER'S INSPECTION

Prior to testing, the purchaser's inspector(s) shall be permitted to inspect the testing machine and end blocks. The testing machine must be in satisfactory condition and shall have been checked or recalibrated by a recognized authority within the past 12 months. The end blocks in the tensile machine should be properly contoured so that the chain links will not be notched or indented in any way.

4.9 BREAK TEST

Break tests shall be conducted. A specimen consisting of at least three links shall be tested for each length of chain as indicated in Table 6. Each specimen shall be subjected to the breaking load specified in Table 6 or Table 7. Specimens shall be manufactured at the same time as the length of chain and attached so that they will be heat treated along with the length of chain. The specimen will be considered to have successfully passed the test if there is no sign of fracture after application of the required load. If the first test fails, one additional specimen may be cut out of the same length of chain at a point adjacent to where the first specimen was removed and subjected to the specified breaking load. If the second specimen fails, the length of chain shall be rejected.

4.10 PROOF TESTS

All chain shall withstand the applicable proof test load indicated in Table 6 or Table 7. If one link breaks under the proof load, an approved connecting link shall be inserted and the proof test again applied; if a second link breaks under the proof load, the length of chain between the end blocks shall be rejected.

4.11 LENGTH OVER FIVE LINKS—PITCH LENGTH

After proof testing, the entire chain shall be checked for length, five links at a time, to ensure that the chain falls within the tolerances shown in Table 6 or Table 7. In this five-link check, the first five links shall be measured. Then for the next set of five links, two links from the previous five links shall be included. This procedure shall be followed throughout the entire length of chain. The measurement shall be taken while the chain is loaded to 10 percent of the proof load. If the length of chain over five links is short, the chain may be stretched by loading above the proof test load specified in Table 6 or Table 7 provided (a) that this load does not exceed the proof load by 10 percent and (b) that only random lengths of the chain need stretching. If loading is required to stretch the chain, the final load and the chain length number should be noted on the inspection report. If the length of chain over five links exceeds the tolerances given in Table 6 or Table 7, the links which fail to meet the specified tolerances shall be cut out. An approved connecting link shall be inserted. The links held in the end blocks may be excluded from this measurement. Special written approval is required in advance of chain manufacture where alterations to this procedure are required.

4.12 INSPECTION OF FLASH WELD

After proof testing, the flash weld of every link shall be inspected by the magnetic particle method as per ASTM E 709 and E 1444, in the transverse direction—100 percent of the links. If an indication in the weld is found, the area

Table 6—Mooring Chain Proof and Break Tests, Length Over Five Links, and Approximate Weight (Customary Units)

Nominal Diameter, *d*	Proof Test Load	Break Test Load	Chain Length Over 5 Links, Inches		Approximate Weight
			Minimum	Maximum	
Inches	1000 Pounds	1000 Pounds			Pound-Feet
1 3/8	158.0	238.0	30.25	31.00	18
1 1/2	187.0	282.0	33.00	33.80	22
1 5/8	218.0	329.0	35.75	36.65	25
1 3/4	251.0	379.0	38.50	39.45	29
1 7/8	287.0	432.0	41.25	42.25	33
2	324.0	489.0	44.00	45.10	37
2 1/8	364.0	548.0	46.75	47.95	42
2 1/4	405.0	611.0	49.50	50.75	47
2 3/8	449.0	676.0	52.25	53.55	53
2 1/2	494.0	744.0	55.00	56.40	59
2 5/8	541.0	815.0	57.75	59.20	65
2 3/4	590.0	889.0	60.50	62.00	71
2 7/8	640.0	965.0	63.25	64.85	78
3	693.0	1044.0	66.00	67.65	85
3 1/8	747.0	1125.0	68.75	70.75	92
3 1/4	802.0	1209.0	71.50	73.25	100
3 3/8	859.0	1295.0	74.25	76.10	108
3 1/2	918.0	1383.0	77.00	78.95	117
3 5/8	977.0	1473.0	79.75	81.75	126
3 3/4	1039.0	1566.0	82.50	84.55	133
3 7/8	1101.0	1660.0	85.25	87.40	143
4	1165.0	1756.0	88.00	90.20	152
4 1/8	1231.0	1855.0	90.75	93.00	162
4 1/4	1297.0	1955.0	93.50	95.85	171
4 3/8	1365.0	2057.0	96.25	98.65	180
4 1/2	1433.0	2160.0	99.00	101.48	190
4 5/8	1503.0	2265.0	101.75	104.29	200
4 3/4	1574.0	2372.0	104.50	107.11	210
4 7/8	1645.0	2479.0	107.25	109.93	221
5	1718.0	2589.0	110.00	112.75	232
5 1/8	1791.0	2700.0	112.75	115.57	244
5 1/4	1865.0	2811.0	115.50	118.39	262
5 3/8	1941.0	2925.0	118.25	121.21	267
5 1/2	2016.0	3038.0	121.00	124.03	287
5 5/8	2093.0	3154.0	123.75	126.84	290
5 3/4	2170.0	3270.0	126.50	129.66	300
5 7/8	2247.0	3387.0	129.25	132.48	328
6	2325.0	3504.0	132.00	135.30	323
6 1/8	2404.0	3623.0	134.75	138.12	336
6 1/4	2483.0	3742.0	137.50	140.94	372
6 3/8	2562.0	3861.0	140.25	143.76	387
6 1/2	2642.0	3981.0	143.00	146.58	402
6 5/8	2722.0	4102.0	145.75	149.39	418
6 3/4	2802.0	4223.0	148.50	152.21	434
6 7/8	2882.0	4344.0	151.25	155.03	450
7	2963.0	4465.0	154.00	157.85	467

Note:
Any nominal diameter not included on the above table may be calculated by the following formulas:

U.S. Customary Units

Proof test load = $2030.5\ d^2(44–2.032d)$
Break test load = $3060.3\ d^2(44–2.032d)$
Chain weight = $9.50d^2$
Chain length over 5 links: minimum = $22d$, maximum = $22.55d$

Table 7—Mooring Chain Proof and Break Tests, Length Over Five Links, and Approximate Weight (SI Units)

Nominal Diameter, *d*	Proof Test Load	Break Test Load	Chain Length Over 5 Links		Approximate Weight
			Millimeters		
Millimeters	Kilonewtons	Kilonewtons	Minimum	Maximum	Kilograms per meter
34	668	1007	748	767	25
38	828	1248	836	857	32
42	999	1513	924	947	39
44	1097	1654	968	992	42
48	1295	1952	1056	1082	50
50	1400	2110	1100	1128	55
54	1620	2441	1188	1218	64
58	1854	2794	1276	1308	74
60	1976	2978	1320	1353	79
64	2230	3360	1408	1443	90
66	2361	3559	1452	1488	95
70	2634	3970	1540	1578	107
73	2846	4291	1606	1646	117
76	3066	4621	1672	1714	127
79	3292	4962	1738	1803	137
83	3603	5430	1826	1872	151
85	3762	5671	1870	1917	159
87	3924	5916	1914	1962	166
92	4342	6544	2024	2075	185
95	4599	6932	2090	2142	198
98	4862	7328	2156	2210	210
102	5220	7868	2244	2300	228
105	5495	8282	2310	2368	241
108	5774	8702	2376	2435	255
111	6058	9130	2442	2503	270
114	6346	9565	2508	2571	285
117	6639	10,005	2574	2638	300
121	7035	10,602	2662	2729	321
124	7336	11,057	2728	2796	337
127	7641	11,516	2794	2864	353
130	7950	11,981	2860	2932	370
133	8261	12,451	2926	2999	387
137	8682	13,085	3014	3089	411
140	9000	13,564	3080	3157	429
143	9321	14,049	3146	3225	448
146	9645	14,536	3212	3292	467
149	9971	15,028	3278	3360	486
152	10,299	15,522	3344	3428	506
156	10,739	16,185	3432	3518	542
159	11,071	16,686	3498	3585	554
162	11,405	17,189	3564	3653	575
165	11,739	17,693	3630	3721	596
168	12,075	18,199	3696	3788	618
171	12,412	18,707	3762	3856	640
175	12,863	19,386	3850	3946	671
178	13,201	19,896	3916	4014	694

Note:
Any nominal diameter not included on the above table may be calculated by the following formulas:

Metric (SI) Units

Proof test load = $0.014\ d^2(44-.08d)$

Break test load = $0.0211\ d^2(44-.08d)$

Chain weight = $0.0219d^2$

Chain length over 5 links: minimum = $22d$, maximum = $22.55d$

shall be ground no more than 5 percent of bar diameter and rechecked by magnetic particle inspection. If the indication is still present, the link shall be cut out.

Any bar stock misalignment that exceeds ±2½ percent of the bar diameter in the flash butt-weld area will require the removal of the affected link.

All links removed shall be replaced with approved connecting links or splice links.

In addition to the 100 percent magnetic particle inspection, a 10 percent ultrasonic inspection of the specified length, as per Table 4, shall be performed on the selected link's flash weld interior. Both sides of the heat-affected zone shall be inspected with the appropriate type transducers. The acceptance and rejection criteria can either be that of the DNV Certification Notes 2.6, July 1985, or as per agreement between manufacturer, customer, and inspection agency. All links removed shall be replaced with approved connecting links. No more than two connecting links per 1000 feet (300 meters) of chain or portion thereof shall be allowed.

A splice link may be used to replace a rejected link, an average of one splice link per 100 feet (30.5 meters) is allowed. The link shall be heat-treated, inspected, and tested per Table 6 or 7. A second link shall be made *identical* to the splice link; the link shall be tested and inspected per Table 2 after proof testing per Table 6 or 7. If the test link does not pass the applicable test, the splice link shall be removed. The replacement link shall be ultrasonically inspected per DNV Certification Notes 2.6.

A splice link is defined as a specially approved common link that is used to connect two lengths of chain. This link replaces one that is rejected at inspection after heat treatment.

4.13 INSPECTION OF CHAIN LINKS FOR SURFACE DEFECTS

All links shall be visually inspected for deficiencies such as mill defects, surface cracks, dents, cuts, incorrect placement of stud, or failure to weld the stud. Rough edges shall be ground smooth. Any cracks, dents, or cuts shall be ground down (no more than 5 percent of bar diameter) and streamlined to provide no reentry contours and then be rechecked. Grinding shall be in the longitudinal direction. Inspection grinding shall be faired to a minimum length of six times grinding depth. If the link still has a surface defect, it shall be cut out. Alignment of the stud shall conform with the requirements in Table 5 and Figure 3. If the stud is out of alignment, the link shall be cut out. The link shall be cut out if there is excessive penetration of the stud into the link. All links removed shall be replaced with approved connecting links or splice links. No more than two connecting links per 1000 feet (300 meters) of chain or portion thereof shall be allowed. At least one stud weld within each maximum specified length (Table 4) shall be checked by dye penetrant techniques after the chain is proof tested. If a crack is found, stud welds in the adjacent links should be checked. If cracks are found in either adjacent link, all links within the maximum specified length (Table 4) shall be inspected.

4.14 LINK DIMENSIONS

After proof testing, measurements shall be taken on at least one link in accordance with the frequency of testing specified in Table 4 and the results shall be recorded and made available to the purchaser's inspector(s). The link dimensions to be measured are shown in Figure 3. The bar diameter at each end of the elliptical portion of the link may be slightly smaller than the original bar diameter as a result of being bent around the anvil during manufacture. The outside radius R of each end of the link shall be symmetrical to ensure proper fit and function in the chain-handling equipment.

4.15 TESTS TO DETERMINE MECHANICAL PROPERTIES OF CHAIN

One link for every length of chain indicated in Table 4 shall be removed for a set of mechanical tests consisting of one tensile and six impact tests. This link shall be removed at the same time and at the same location as the break test specimens. Three impact test specimens shall be taken across the weld and three impact test specimens shall be taken across the unwelded side of the link. The specimens shall be cut and notched in accordance with the requirements of 3.7. The notch must be precisely bottomed in the flash weld line for the three specimens taken from the side of the link. The tensile specimen shall be taken from the side opposite the flash weld. The same test procedures and rejection criteria described in 3.4 through 3.7 shall be followed. All heat treating equipment shall be automatically controlled and regularly checked; continuous temperature-versus-time records are required. Results of these tests and temperature-time charts shall be made available to the purchaser's inspector. For low-temperature application, optional Charpy tests may be conducted (see Table 2).

4.16 CHAIN WEIGHT

All finished chain shall be weighed; weight may be extended from representative chain sample.

4.17 MARKING AND CERTIFICATION

For API monogram licenses, the manufacturer shall mark each test report with the API monogram to certify that the chain covered by the report complies with all requirements of this specification. The API monogram shall be applied only by authorized manufacturers. It shall be applied by imprinting, stamping, or stenciling and shall be of such size and location as to be plainly visible.

Stamping shall be made with low-stress stamps and shall be located on the side wires of the link or on the stud. Stamping on the stud is acceptable. A minimum of two links, one on each end, shall be stamped with API monogram and certification requirements.

Each length of chain shall have an associated report which contains documented requirements of this specification. It shall contain all test results, material certification, number of links, inspection results and identification of any rejected test and splice links.

5 Kenter Link Requirements and Tests

5.1 GENERAL

The following special provisions apply to the testing and acceptance of forged kenter-type anchor connecting links (shackles) which will be used in conjunction with flash-welded anchor chain. Other types of anchor chain connecting links may be acceptable; however, this section deals only with forged kenter-type connecting links.

5.2 MATERIAL COMPOSITION

The chemical composition of kenter links shall be at the manufacturer's option; however, the maximum sulphur (S) and phosphorus (P) content will be 0.035 percent, respectively. When different size kenter links are manufactured from the same heat of steel, the variation in size of the links shall not be more than 1 inch (25 millimeters) absolute. The taper pin is to be stainless steel. A lead plug is to be furnished with each assembly to secure taper pin.

5.3 MECHANICAL PROPERTIES

Mechanical tests (tensile and impact) shall be conducted on the raw material as well as the finished links as follows:

5.3.1 Raw Material

Mechanical tests (tensile and impact) shall be conducted for each heat in accordance with 3.3 through 3.7, inclusive, except in reference to weld and flash weld tests.

5.3.2 Forged Link

One forged kenter link from each heat, having been forged, but not necessarily machined, shall be used as a test specimen for the mechanical properties (tensile and Charpy) per 4.15, except in reference to welds and flashzone tests.

5.4 SURFACE INSPECTION

All kenter links shall be inspected after proof testing per 5.7 by magnetic particle or other suitable method to assure freedom from injurious defects per 4.13, except in reference to studs and specified length requirements.

5.5 HARDNESS TESTS

A Brinell hardness test shall be made on all kenter links. The test shall be made at the wire diameter section (Dimension d) using a 10-millimeter ball and a 3000-kilogram load. The minimum hardness shall be 195 BHN.

5.6 BREAK TEST

A break test shall be made on 1 link out of every lot of 25 or less, which is of the same size and heat treatment, but not necessarily representative of each heat of steel, heat-treat charge, or individual purchase order. The break tests are to be conducted in accordance with 4.9 and shall be within the values given in Table 6 or Table 7. If a kenter link fails to meet the values given in Table 6 or Table 7, the lot shall be rejected.

5.7 PROOF TEST

Each kenter link shall be proof tested in accordance with 4.10 and the resulting values shall be in accordance with Table 6 or Table 7.

5.8 DIMENSIONS

After proof testing, measurements shall be made on at least 1 link out of 25 per 4.6 and shall comply to the nominal dimensions and tolerances given in Figure 4 and Table 8. If the kenter link does not meet the dimensions and tolerances given in Table 8, it shall be rejected and each individual link in the lot of 25 shall be inspected for acceptance or rejection, per Table 8.

5.9 FITTING OF COMMON SHAPES TO KENTER LINKS

Figure 5, in conjunction with Figure 4 and Table 8, shows three representative shapes (straight bar, U-type shape, and circle) which may be required to fit within a forged kenter connecting link. Figure 5 is for guidance in ordering associated accessories in which forged kenter connecting links may be used. A 2-percent loose fit tolerance has been taken into account assuming maximum or minimum compatible tolerances have occurred with the forged kenter link.

5.10 WEIGHT

All finished kenter links shall be weighed and the weight recorded on the test report along with the nominal dimensions per 5.8.

5.11 FINISH

After the kenter links have been fully tested and passed all specified tests, they shall be thoroughly cleaned and one heavy coat of asphalt varnish or equivalent applied to the assembled link(s). The method of application shall be by dipping the completely assembled link into the preservative.

5.12 MARKING AND CERTIFICATION

The manufacturer shall mark each test report and each forged kenter connecting link in accordance with 4.17. All component parts of a kenter link shall be stamped with a serial number to avoid mixing components.

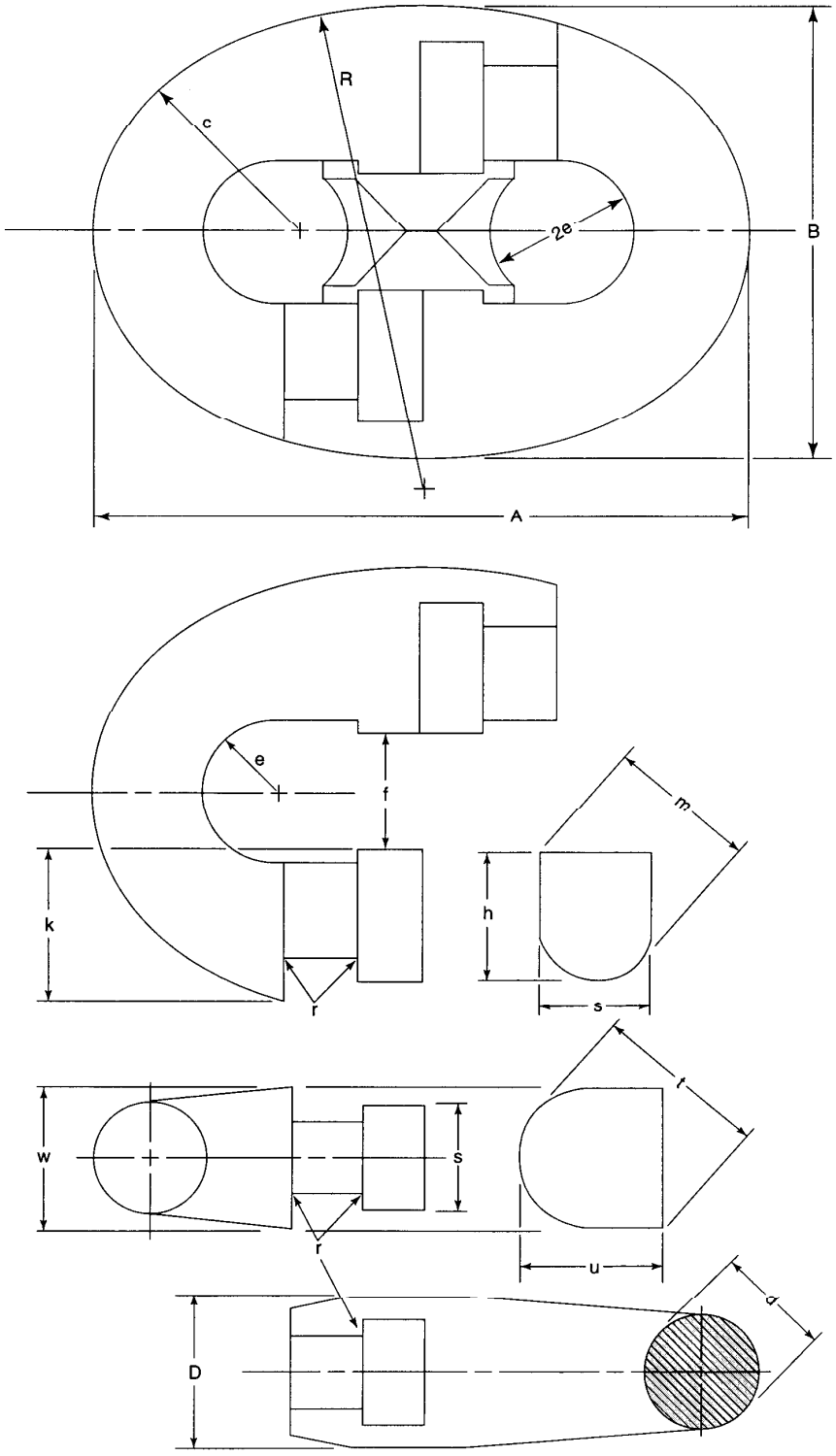
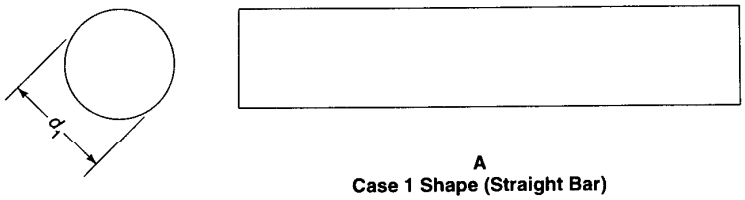


Figure 4—Kenter Link Critical Dimensions

Table 8—Kenter Link Dimensions and Tolerances (See Figure 4)

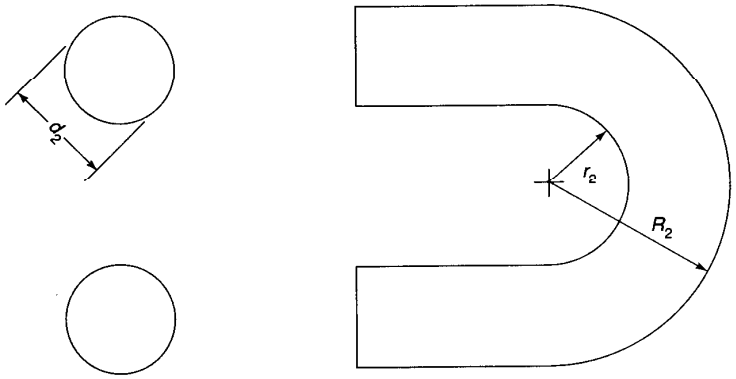
Dimension Designation (See Figure 4)	Nominal Dimension Times *d*	Tolerance (%)		Remarks
		Minus	Plus	
A	6.00	2.0	2.0	
B	4.20	2.0	2.0	
c	1.83	2.5	2.0	
e	0.67	0.0	2.5	
R	4.50	2.5	2.0	Controlled by A, B and c
k	1.40	2.5	2.0	
s	1.10	2.5	2.5	
m	1.45	2.5	2.5	Controlled by s and h
n	1.32	2.5	2.5	
w	1.34	2.5	2.0	
f	1.13	0.0	2.5	
t	1.59	2.5	2.0	Controlled by u and w
u	1.30	2.5	2.0	
D	1.52	2.5	2.0	
d	1.00	2.0	2.0	Tolerances not additive for *d*
r	0.03[a]	—	—	

Notes:
Plus and minus tolerances between various dimensions must be compatible.
The machine surfaces shall comply with the International Standard of Tolerances ISO/R286-1962, Code H11, h11.
Shot peening in the r areas can be considered to prolong fatigue life.
[a]This is the required minimum value.



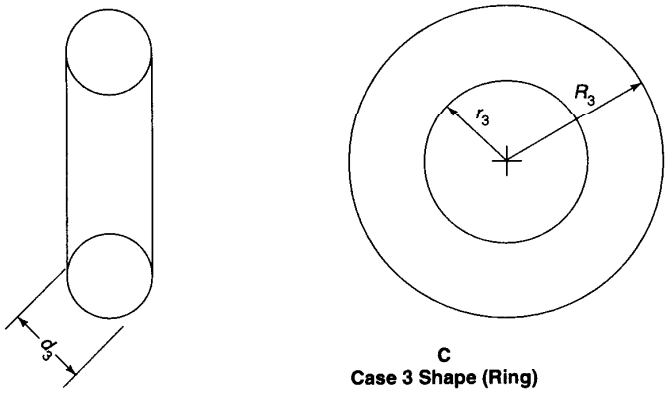
Max d_1 = 1.31d

A
Case 1 Shape (Straight Bar)



Max d_2 = 1.31d
Min r_2 = 0.51d
R_2 controlled
by d_2 Max & r_2 Min

B
Case 2 Shape ("U" Type)



Min d_3 = N < or unrealistic
Max d_3 = 1.11d but unrealistic
since R_3 & r_3 would have
to be infinite
Min r_3 = 0.84d with a max
r_3 = 1.60d & d_3 = 0.76d*
Max r_3 = N < or unrealistic
Min R_3 = r_3 Min = 0.84d
Max R_3 = N < or unrealistic

C
Case 3 Shape (Ring)

Notes:
d = Nominal kenter size.
*Dimension U & W control in conjunction with F.

Figure 5— Critical Shapes to Be Mated With API Kenter Link

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