



## Specification

General Electric Company

Document No. **B5F4**Issue No. **S23**Orders and Correspondence Must  
Specify Complete Material Number**Chromium-Molybdenum Steel Bar**

GE Material B5F4 identifies chromium-molybdenum low alloy steel bar, as follows:

GE designation			Description
AISI	AISI 4140 or 4142	AISI 4140, 4142 or 4145	
B5F4A	—	—	Chemical base, hot-rolled
B5F4B	B5F4F	—	Hot-rolled, annealed, machine straightened
B5F4B2	—	—	Hot-rolled, annealed, centerless ground, special tolerances
B5F4C	B5F4H	—	Hot-rolled, heat-treated, machine straightened, stress relieved For Turbine Business, commercial applications, B5F4C is replaced by B5F4C11 and B5F4H is replaced by B5F4H11
B5F4C2	B5F4H2	—	Hot-rolled, heat-treated, machine straightened, stress relieved
B5F4C4	—	—	Hot-rolled, heat-treated, machine straightened, stress relieved
B5F4C11	B5F4H11	—	Hot-rolled, heat-treated, machine straightened, stress relieved, magnetic particle sample inspected for steel cleanliness
B5F4D	B5F4K	—	Cold-finished, annealed, machine straightened
B5F4D2	B5F4K2	—	Cold-finished, heat-treated, machine straightened, stress relieved
—	—	B5F4M	Hot-rolled, heat-treated, bolting material bar stock, Grade B7 (1)

- (1) The requirements for B5F4M are equal to or more restrictive than those delineated in the latest revision of the ASME Boiler and Pressure Vessel Code Specification SA-193, Grade B7. A certification stating that the material meets SA-193 Grade B7 is required of the supplier.

## CHEMICAL COMPOSITION: % (Heat analysis) (2)

	B5F4A, B, B2, C, C2, C4, C11, D, D2	B5F4F, H, H2, H11, K, K2	B5F4M
Carbon .....	0.40-0.45	0.38-0.45	0.38-0.48
Manganese .....	0.75-1.00	0.75-1.00	0.75-1.00
Phosphorus, max .....	0.025	0.025	0.025
Sulfur, max .....	0.025	0.025	0.025
Silicon .....	0.15-0.35	0.15-0.35	0.15-0.35
Chromium .....	0.80-1.10	0.80-1.10	0.80-1.10
Molybdenum .....	0.15-0.25	0.15-0.25	0.15-0.25

The heat analysis (formerly ladle analysis) made by the manufacturer to determine the percentages of the elements required under this specification shall be reported to the purchaser or his representative in a certificate of test when specified on purchase order or otherwise.

A product analysis (formerly check analysis) may be made by the purchaser from a sample representing each melt. The chemical composition thus determined shall conform to the requirements of this specification within the ASTM A193 Standard permissible variation for product analysis.

- (2) Calcium metal, calcium containing ferro-alloys or compounds containing calcium may be added to the molten steel in the ladle. After solidification, inclusions resulting from the additions shall be spherical in configuration. Stringer type inclusions containing calcium are unacceptable.

(Continued on page 2)

## Chromium-Molybdenum Steel Bar

### MECHANICAL PROPERTIES:

GE designation	Outside diameter or overall thickness, in	Tensile strength, ksi, min	Yield strength, ksi, min	Elongation in 2 inch, %, min	Reduction of area, %, min	Hardness, Brinell, HB
B5F4B, B2, F	All sizes	—	—	—	—	212 max
B5F4D, K	All sizes	—	—	—	—	229 max
B5F4C, C11, D2, H, H11, K2	Up to 2 incl	125	100 (3)	16	45	302 max
	Over 2–4 incl	115	95 (3)	16	45	302 max
	Over 4–7 incl	110	85 (3)	16	45	302 max
B5F4C2, H2	Up to 2 incl	105	80 (3)	20	50	255 max
	Over 2–4 incl	100	75 (3)	20	50	255 max
	Over 4–7 incl	95	70 (3)	20	50	255 max
	Over 7	90	65 (3)	20	50	255 max
B5F4C4	Up to 4 incl	120	95 (3)	16	45	241–302 (5)
	Over 4–10 incl	110	85 (3)	16	45	302 max
B5F4M	Up to 2 1/2 incl	125	105 (4)	16	50	—
	Over 2 1/4 incl	115	95 (4)	16	50	—
	Over 4–7 incl	100	75 (4)	18	50	—

(3) At 0.02 % offset.

(4) At 0.2 % offset.

(5) The minimum Brinell hardness is required throughout the cross-sectional area.

### MECHANICAL TESTS:

**Test specimens** – Test specimens may be taken from any bar. The axis of the specimen shall be located at the center of bars not over 1 1/2 inch in diameter or width. From round, hexagon or square bars, more than 1 1/2 inch in diameter or width, the axis of the specimen shall be located midway between the center and the surface of the bar. From rectangular bars more than 1 1/2 inch wide, the axis of the specimen shall be located midway between the surface bounding the thickness of the bar and midway between the center and the edge of the bar.

**Number of tests** – Two tension tests shall be made from each tempering charge. If more than one quenching charge is represented in a tempering charge, two tension tests shall be made from each quenching charge. If more than one melt is represented in a quenching charge two tension tests shall be made from each melt. When heat treated without interruption in continuous furnaces, the material in a lot shall be the same heat, same prior condition, same size, and subjected to the same heat treatment. Not fewer than two tension tests shall represent a lot selected on the basis of one tension test from each 10,000 pounds.

**Retests** – If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted. If the percentage elongation of any test specimen is less than that specified and any part of the fracture is more than 3/8 of the gage length from the middle of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

**Hardness tests** – Unless otherwise specified, hardness tests shall be performed after final heat treatment including stress relief. Bars shall be tested by obtaining readings from a flat surface, ground from the periphery or on the end. These readings shall be taken on the surface for GE Materials B5F4B, B2, D, F, and K and all bars up to 1 1/2 inches in diameter or thickness. Readings on all other bars shall be taken midway between the center and surface. At least two bars shall be hardness tested for each 2,000 pounds of steel shipped, with a minimum of two bars to be tested to represent each lot.

**Material capability** – Material furnished to B5F4A, B, B2, D, F, and K is intended for heat treating to the mechanical properties of B5F4C, C2, C4, C11, D2, H, H2, H11 and K2.

**Reporting** – Mechanical tests reported in the certificate of test shall be performed on the bar material after all manufacturing operations, which can affect the mechanical properties and microstructure of the bar, have been completed. Such operations include bar straightening and stress-relief treatments.

### ADDITIONAL REQUIREMENTS:

**Process** – Material shall be made by the electric furnace or basic oxygen process, unless otherwise specified. Secondary refining and ladle processing methods are acceptable.

**Imperfections** – The metal shall be homogeneous throughout and shall be free from hard spots, seams, slag, folds, or other imperfections which would tend to impair its value.

**Processing** – Material shall be processed in the order as indicated under "Description" in the introductory paragraph followed by tension and hardness tests where required to meet the mechanical properties.

(Continued on page 3)

## Chromium-Molybdenum Steel Bar

### ADDITIONAL REQUIREMENTS: (Continued)

**Machinability** (Excluding GE Material B5F4A) – As received, bars produced to all other designations shall be capable of being machined using normal procedures without displaying excessive material or dimensional imperfections including excessive amounts of distortion or camber.

**MPI, GE Materials B5F4C11 and B5F4H11** – Material ordered by Turbine Business Operations, for commercial application to GE Designations B5F4C and B5F4H, and material ordered to B5F4C11 and B5F4H11, shall be magnetic particle inspected using the direct current, continuous, wet method in accordance with the requirements of AMS 2301 and AMS 2640. Sampling and testing, plus acceptance and reporting shall be in accordance with AMS 2301, aircraft quality steel cleanliness.

**Straightening and cold working** – Unless otherwise approved by the purchaser, all cold working and straightening shall be performed prior to the final heat treatment or stress-relief cycle (See stress relief below).

### HEAT TREATMENT:

- A. **Slow cooling** – Immediately after rolling, hot wrought bars shall be allowed to cool to a temperature below the critical range under suitable conditions to prevent injury by too rapid cooling.
- B. **Annealing** (GE Designations B5F4B, B2, D, F and K) – Bars produced to these designations shall be heat treated by heating slowly to a suitable temperature, held for a suitable time and slow cooled to soften the material and minimize residual thermal stresses.
- C. **Quench and temper** (GE Designations B5F4C, C2, C4, C11, D2, H, H2, H11 and K2) – Heat treatment of these materials shall include quenching and tempering. Bars shall be uniformly heated to the austenitizing temperature soaked for a sufficient length of time to produce complete transformation (a lot thus heated being known as a quenching charge) and quenched in a suitable medium under substantially uniform conditions for each quenching charge. The bars shall then be uniformly reheated to a minimum tempering temperature of 1,100 °F, (a lot thus reheated being known as a tempering charge) and held for a sufficient time to be determined and allowed to cool uniformly. The exact tempering time and temperature shall be as required to provide that the bars be capable of meeting the mechanical property requirement specified.
- D. **Alternate treatment** (GE Designation B5F4M) – In addition to requirements specified in (C), including quenching in a suitable medium, bars may be specified to be furnished in the normalized or air-quenched condition. Bars specified to be normalized or air quenched shall be heated to an austenitizing temperature suitable to refine the grains and cooled uniformly in air to a temperature below the cooling critical range. The bars shall then be tempered as outlined in (C).
- E. **Stress relief** (GE Designations B5F4C, C2, C4, C11, D2, H, H2, H11 and K2) – Hot-wrought or cold-finished bars which are straightened by any method, including localized gag or press straightening, require a stress relief following the final straightening operation. The stress relief shall not be lower than 100 °F below the final tempering temperature.

### IDENTIFICATION:

Unless otherwise specified on the purchase order, heat numbers shall be stamped on each bar where this does not incur an extra charge. Those sizes which incur an extra charge shall be tagged, or bundled and tagged with the heat number.

### REFEREE METHODS:

Chemical composition .....	ASTM A751
Tension test .....	ASTM A370
Hardness .....	ASTM A370
Magnetic particle inspection, dc .....	AMS 2301 and AMS 2640

(Continued on page 4)



## Chromium-Molybdenum Steel Bar

### TOLERANCES:

Diameter, thickness and width:

#### ROUNDS AND SQUARES (B5F4A, B, C, C2, C4, C11, F, H, H2, H11, M)

Specified size, inch		Tolerance, inch		
Over	To incl	Over	Under	Out of round or square (6) (7)
—	5/16	0.005	0.005	0.008
5/16	7/16	0.006	0.006	0.009
7/16	5/8	0.007	0.007	0.010
5/8	7/8	0.008	0.008	0.012
7/8	1	0.009	0.009	0.013
1	1 1/8	0.010	0.010	0.015
1 1/8	1 1/4	0.011	0.011	0.016
1 1/4	1 3/8	0.012	0.012	0.018
1 3/8	1 1/2	0.014	0.014	0.021
1 1/2	2	1/64	1/64	0.023
2	2 1/2	1/32	0	0.023
2 1/2	3 1/2	3/64	0	0.035
3 1/2	4 1/2	1/16	0	0.046
4 1/2	5 1/2	5/64	0	0.058
5 1/2	6 1/2	1/8	0	0.070
6 1/2	8 1/4	5/32	0	0.085
8 1/4	9 1/2	3/16	0	0.100

- (6) Out-of-round is the difference between the maximum and minimum diameters of the bar, measured at the same cross section.
- (7) Out-of-square is the difference in the two dimensions at the same cross section of a square bar, each dimension being the distance between opposite sides.

#### HEXAGONS AND OCTAGONS (B5F4A, B, C, C2, C11, F, H, H2, H11)

Specified size, inch		Size tolerance, inch		
Over	To incl	Over	Under	Dif 3 meas (8)
—	1/2	0.007	0.007	0.011
1/2	1	0.010	0.010	0.015
1	1 1/2	0.021	0.013	0.025
1 1/2	2	1/32	1/64	1/32
2	2 1/2	3/64	1/64	3/64
2 1/2	3 1/2	1/16	1/64	1/16

- (8) Hexagons only.

#### HEXAGONS (B5F4C4)

Specified size, inch		Tolerance, inch, minus only	
Over	To incl	Under	Dif 3 meas
—	1/2	0.014	0.011
1/2	1	0.020	0.015
1	1 1/2	0.034	0.025
1 1/2	2	3/64	1/32
2	2 1/2	1/16	3/64
2 1/2	3 1/2	5/64	1/16

(Continued on page 5)

**Chromium-Molybdenum Steel Bar****TOLERANCES: (Continued)**

Diameter, thickness and width: (Continued)

FLATS (B5F4A, B, C, C2, C4, C11, F, H, H2, H11)

Specified width, inch		Tolerance, width, inch		Tolerance, thickness, over or under, inch						
Over	To incl	Over	Under	0.203-0.230 inch thick, excl	0.230-1/4 inch thick, excl	1/4-1/2 inch thick, incl	Over 1/2-1 inch thick, incl	Over 1-2 inch thick, incl	Over 2-3 inch thick, incl	Over 3 inch thick
-	1	1/64	1/64	0.007	0.007	0.008	0.010	-	-	-
1	2	1/32	1/32	0.007	0.007	0.012	0.015	1/32	-	-
2	4	1/16	1/32	0.008	0.008	0.015	0.020	1/32	3/64	3/64
4	6	3/32	1/16	0.009	0.009	0.015	0.020	1/32	1/16	1/16
6	8	1/8 (9)	3/32 (9)	-	0.015	0.016	0.025	1/32	1/16	-

(9) Shall not apply to flats over 3 inches thick.

Length: (Hot-shearing) (B5F4A, B, C, C2, C4, C11, F, H, H2, H11)

Rounds, squares, hexagons, octagons:

Specified size of round, square, hexagon, octagon, inch	Tolerance, plus, inch, no tolerance minus				
	5-10 feet long, excl	10-20 feet long, excl	20-30 feet long, excl	30-40 feet long, excl	40-60 feet long, excl
To 1 incl	1/2	3/4	1 1/4	1 3/4	2 1/4
Over 1-2 incl	5/8	1	1 1/2	2	2 1/2
Over 2-5 incl	1	1	1 3/4	2 1/4	2 3/4
Over 5-9 1/2 incl	2	2	2 3/4	3	3 1/4

Flats:

Specified size of flats, inch		Tolerance, plus, inch, no tolerance minus				
Thickness	Width	5-10 feet long, excl	10-20 feet long, excl	20-30 feet long, excl	30-40 feet long, excl	40-60 feet long, incl
To 1 incl	To 3 incl	1/2	3/4	1 1/4	1 3/4	2 1/4
Over 1	To 3 incl	5/8	1	1 1/2	2	2 1/2
To 1 incl	Over 3-6 incl	5/8	1	1 1/2	2	2 1/2
Over 1	Over 3-6 incl	1	1 1/2	1 3/4	2 1/4	2 3/4
1 incl	Over 6-8 incl	3/4	1 1/4	1 3/4	3 1/2	4
Over 1-3 incl	Over 6-8 incl	1 1/4	1 3/4	2	3 1/2	4

Diameter: (B5F4B2)

Diameter, inch	Tolerance, inch	
	Over	Under
Up to 9/32 incl	0.001	0.001
Over 9/32-15/32 incl	0.0015	0.0015
Over 15/32-31/32 incl	0.002	0.002
Over 31/32 -1 15/32 incl	0.005	0
Over 1 15/32-4 incl	0.006	0

Diameter, thickness and width: (B5F4D, K)

**ROUNDS**

Diameter, inch		Tolerance, inch, minus only
Over	To incl	
-	1	0.005
1	2	0.006
2	4	0.007
4	6	0.008
6	7 3/4	0.010

(Continued on page 6)



## Chromium-Molybdenum Steel Bar

**TOLERANCES: (Continued)**

Diameter, thickness and width: (B5F4D, K) (Continued)

### HEXAGONS AND SQUARES

Distance between parallel surfaces, inch		Tolerance, inch, minus only	
Over	To incl	Hexagons	Squares
—	3/4	0.005	0.006
3/4	1 1/2	0.006	0.007
1 1/2	2 1/2	0.007	0.008
2 1/2	3 1/8	0.008	—
2 1/2	4	—	0.010

### FLATS

Width, inch		Tolerance, inch, minus only (10)
Over	To incl	
—	3/4	0.007
3/4	1 1/2	0.009
1 1/2	3	0.011
3	4	0.012
4	6	0.013

(10) Applies to thickness as well as width.

### ROUNDS

Diameter, inch		Tolerance, inch, minus only
Over	To incl	
—	1	0.007
1	2	0.009
2	4	0.011
4	6	0.013
6	7 3/4	0.017

### HEXAGONS AND SQUARES

Distance between parallel surfaces, inch		Tolerance, inch, minus only	
Over	To incl	Hexagons	Squares
—	3/4	0.007	0.008
3/4	1 1/2	0.008	0.009
1 1/2	2 1/2	0.009	0.010
2 1/2	3 1/8	0.010	—
2 1/2	4	—	0.012

### FLATS

Width, inch		Tolerance, inch, minus only (11)
Over	To incl	
—	3/4	0.009
3/4	1 1/2	0.011
1 1/2	3	0.013
3	4	0.017
4	6	0.021

(11) Applies to thickness as well as width.

(Continued on page 7)

# Chromium-Molybdenum Steel Bar

## TOLERANCES: (Continued)

Length: (B5F4B2, D, D2, K, K2)

Random:

Length, feet	Length range, inch
5-20 incl	24
Over 20-30 incl	36
Over 30-40 incl	48

Specific: (Machine cut)

Diameter or distance between parallel surfaces, inch		Length tolerance, inch			
		Up to 12 feet incl		Over 12-25 feet incl	
Over	To incl	Plus	Minus	Plus	Minus
-	3	3/16	1/16	1/4	1/16
3	6	1/4	1/16	3/8	1/16
6	-	3/8	1/16	1/2	1/16

Straightness:

B5F4A only .....  $\frac{1}{4}$  inch in any 5 feet, but may not exceed  $\frac{1}{4} \text{ inch} \times \frac{\text{total length (feet)}}{5}$

B5F4B, C, C2, C4, C11, D, D2, F, H, H2, H11, K, K2 .....  $\frac{1}{8}$  inch in any 5 feet, but may not exceed  $\frac{1}{8} \text{ inch} \times \frac{\text{total length (feet)}}{5}$

## CERTIFICATE OF TEST:

When requested, the supplier shall submit promptly to the purchaser at the point of delivery a certificate of test showing the results of tests for chemical analysis and properties required by this specification. This certificate shall be addressed to the section, unit or person specified on the purchase order, and shall contain the GE designation, the purchase order number, and the quantity shipped so that the certificate may be identified with the shipment.

## PACKING AND MARKING:

Material shall be properly separated by size for shipment, and shall be packed in such a manner as to be suitably protected from injury or loss during shipment.

Each box, crate, bundle, etc., shall be legibly marked with the purchase order number, the manufacturer's name, and the GE designation.

(Continued on page 8)



## Chromium-Molybdenum Steel Bar

### APPENDIX

Included herein are some modified portions of AMS 2301 and AMS 2640 applicable to the magnetic particle testing of bars as required for GE Designations B5F4C11 and B5F4H11.

#### SAMPLING:

##### Heat qualification:

###### Heats of top-poured ingots:

Samples shall be taken from semi-finished or finished product representing the top and bottom of the first ingot and last usable ingot from heats having not more than 10 ingots or not over 30 tons or from portions of heats within these limits; and from the top and bottom of the first, middle, and last usable ingot of heats having more than 10 ingots or over 30 tons.

###### Heats of bottom-poured ingots:

Samples shall be taken from semi-finished or finished product representing the top and bottom of three ingots. One ingot shall be taken at random from the first usable plate (ingot cluster) poured, one ingot at random from the usable cluster poured nearest to the middle of the heat, and one ingot at random from the last usable cluster poured. When a heat is constituted by two usable clusters, two of the sample ingots shall be selected from the second usable cluster poured. When a heat consists of a single usable cluster, any three random ingots may be selected.

###### Less than three ingots:

If there are less than three ingots in the heat, samples shall be taken representing the top and bottom of all ingots.

###### Strand-cast heats:

Samples shall be taken from semi-finished or finished product having at least 3:1 reduction in cross-section from the cast strand (or samples of the as-cast strand similarly reduced) representing the front, middle, and back of both strands when two strands are cast, or of an inside strand and an outside strand when more than two strands are cast. When a single strand is cast, six samples having at least a 3:1 reduction from the cast strand (or samples of the cast strand similarly reduced) representing both ends of the first, middle, and last usable cuts (blooms) of the strand or product shall be taken.

##### Product qualification:

Samples shall be taken at random from not less than 10 % of the pieces of each lot. A lot shall be all product of one size from one heat in one shipment. Not less than 3 nor more than 10 samples shall be selected from a lot, except that if the quantity in the lot is three pieces or less, 1 sample shall be taken from each piece.

##### Round bar test sections:

###### Solid product over 36 square inch cross-sectional area:

A quarter-section shall be cut from the sample sufficiently oversize that the center of the original specimen will be approximately on the surface of the specimen after generating to test size. The specimen shall be converted into test size by machining, or forging and machining, to a diameter not larger than 6 inches consistent with the machining allowance specified. As an alternate method when agreed upon by purchaser and supplier, the full section may be rolled or forged to a 6 inch round or square and an oversize quarter obtained. The identity for specimen surface representing center of original stock shall be maintained throughout machining and testing.

###### Solid product 16-36 square inch, incl, in cross-sectional area:

A quarter-section shall be cut sufficiently oversize that the center of the original specimen will be approximately on the surface of the sample after generating to test size. The specimen shall be converted to test size by machining, or forging and machining, to the largest possible round consistent with the surface representing center of original stock shall be maintained throughout machining and testing.

###### Solid product less than 16 square inch in cross-sectional area except flat bars, slabs, and plates:

The specimens shall be machined, consistent with the machining allowance specified, to straight cylindrical samples. As an alternate method, when agreed upon by purchaser and supplier, a stepdown specimen shall be generated in equal length circumferential steps as in the Table consistent with the machining allowance specified.

Nominal diameter or distance between parallel sides, inch		Step length, inch	Step diameter				
Over	Incl		1	2	3	4	5
incl 0.25	0.50	5.000	D	—	—	—	—
0.50	0.75	2.500	D	2/3D	—	—	—
0.75	1.00	1.665	D	3/4D	1/2D	—	—
1.00	1.50	1.250	D	4/5D	3/5D	2/5D	—
1.50	4.00	1.000	D	4/5D	3/5D	2/5D	1/5D

#### FLAT BAR TEST SPECIMENS:

The type of test, specimen and location in the section shall be as agreed upon by purchaser and supplier.

(Continued on page 9)



**Chromium-Molybdenum Steel Bar**

## APPENDIX (Continued)

**ROUGH MACHINING:****Round bars:**

The converted sample shall be machined to conform to the allowance of the table below for surface removal, allowing 0.010 inch per side for finish machining after heat treatment.

Nominal diameter or distance between parallel sides, inch		Minimum stock removal, inch per side
Over	Incl	
incl 0.25	0.50	0.030
0.50	0.75	0.045
0.75	1.00	0.060
1.00	1.50	0.075
1.50	2.00	0.090
2.00	2.50	0.125
2.50	3.50	0.156
3.50	4.50	0.187
4.50	6.00	0.250

**Flat bars:**

Allowance of 20 % of the nominal thickness or 0.100 inch whichever is less, shall be made for minimum stock removal, allowing 0.010 inch per side for finish machining after heat treatment.

**HEAT TREATING:**

If not already fully heat treated, rough machined samples shall be hardened by austenitizing, quenching and tempering to produce a Brinell hardness of 250 HB minimum.

**FINISH MACHINING:**

The heat-treated specimens shall be finished machined to surface texture not rougher than 40 microinches AA, determined in accordance with ANSI B46.1. Rateable surface of specimens shall be nominally 5 inch in length. The ends of the specimen shall be finished to provide good electrical contact.

**INSPECTION:**

Magnetic particle inspection shall be performed in accordance with AMS 2640 by the circular, wet, continuous method using 800–1,200 ampere per inch (32–48 ampere per millimeter) of diameter. If the stepdown bar is used, the smallest step shall be magnetized and inspected first; the larger steps shall be magnetized and inspected individually in succession of increasing size until all steps have been evaluated.

Cleanliness standards cover nonmetallic inclusions only. Material which, during inspection, reveals indications representing actual ruptures, such as cracks, seams, laminations, and laps, will be subject to rejection except where these indications result from sample preparation.

The results of magnetic particle inspection shall be appropriately recorded. All recorded results shall be identified, filed, and made available to the purchaser upon request.

**EVALUATION OF STEEL CLEANLINESS:**

After inspection, each indication 1/16 inch and over in length shall be recorded. The frequency (number) and severity (size) of the indications shall be calculated as follows:

**Frequency (F):**

Total the number of indications per test specimen.

The frequency per specimen is determined by dividing the total number of indications for each specimen by the area of the test specimen in square inches.

The frequency ratings for all test specimens from a heat are totaled.

The average frequency (F) equals the total frequency rating for all test specimens from a heat divided by the number of test specimens.

**Severity (S):**

Record the length of each indication.

The product for each specimen is computed by totaling the product of the number of indications times the appropriate progression factor listed in the following table:

Length of indication, inch		Progression factor for severity rating
Over	Incl	
incl 1/16	1/8	0.5
1/8	1/4	1
1/4	1/2	2
1/2	3/4	4
3/4	1	8
1	1 1/2	16

(Continued on page 10)

## Chromium-Molybdenum Steel Bar

### APPENDIX (Continued)

#### EVALUATION OF STEEL CLEANLINESS: (Continued)

After inspection, each indication 1/16 inch and over in length shall be recorded. The frequency (number) and severity (size) of the indications shall be calculated as follows: (Continued)

##### Severity (S): (Continued)

Specimens which contain indications representing non-metallic inclusions over 1 1/2 inch in length shall be subject to rejection.

The severity per specimen is determined by dividing the product for each specimen by the area of the specimen in square inches.

The severity ratings for all test specimens from a heat are totaled.

The average severity (S) equals the total severity rating for all test specimens from a heat divided by the number of test specimens.

#### DISPOSITION:

Product inspected in accordance with this specification shall conform to the following maximum frequency and severity ratings.

##### Heat qualification:

Sample	Rating	
	Frequency	Severity
Individual test bar	0.67	0.55
Average of all bars from heat	0.34	0.25

##### Product qualification:

Sample	Diameter, inch	Rating	
		Frequency	Severity
Individual bar	Less than 2.5	1.00	0.95
Individual bar	2.5 and over	0.80	0.67
Average of all bars	1.0 to 2.5, incl	0.85	0.80
Average of all bars	Over 2.5 to 4.0, incl	0.55	0.50
Average of all bars	Over 4.0	0.34	0.25

Product under 1.0 inch in nominal diameter or distance between parallel sides inspected using the straight cylindrical test bars or product less than 16 square inches in cross-sectional area inspected by the alternate step-down specimen shall have maximum average frequency and severity ratings as agreed upon by purchaser and supplier.

#### TESTING AND REPORTING:

##### Responsibility for inspection:

The supplier shall provide all the required test samples and shall be responsible for performing required tests. Results of such tests shall be reported to the purchaser. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to the requirements of this specification.

##### Classification of tests:

Tests to determine conformance to all applicable requirements of this specification are classified as acceptance tests.

##### Heat qualification:

Tests to determine conformance to "heat qualification" requirements, if acceptable, need be conducted only once per heat.

Heats which have been qualified as semi-finished product shall be considered qualified for finished product.

##### Product qualification:

Tests to determine conformance to the requirements of this specification on product not "heat qualified" shall be conducted on product of each size and shape of each lot made from each heat.

##### Sampling:

The sampling shall be performed by the producer for heat qualification. No further sampling by the producer shall be required from a heat which meets the requirements. Sampling procedure on the product shall be as described.

##### Reports:

The vendor of the product shall include the frequency severity rating for each lot in the shipment in addition to other information required by the applicable material specification.

(Continued on page 11)



## Chromium-Molybdenum Steel Bar

### APPENDIX (Continued)

#### RESAMPLING AND RETESTING:

##### Retests:

If any specimen used in the above tests fails to meet the specified requirements, disposition of the heat or lot may be based on the results of testing three additional specimens for each original nonconforming specimen; additional specimens shall be as follows:

##### Heats of top-poured ingots:

One of the additional specimens shall be taken from the same position from product from each of the two available ingots most immediately adjacent in pouring sequence to that from which the originally nonconforming specimen was taken. The third specimen shall be taken from product of the original nonconforming ingot after additional discard. Should the latter specimen be unacceptable, resampling and retesting of the nonconforming ingot may be repeated after as many consecutive discards as necessary to obtain acceptable results. Should any of the adjacent ingot tests fail to meet the specified requirements, resampling and retesting of these ingots will be permitted using the procedure specified for the original nonconforming ingot.

##### Heats of bottom-poured ingots:

One of the additional specimens shall be taken from the same position from product from each of the two available ingots most immediately adjacent to that from which the originally nonconforming specimen was taken. The third specimen shall be taken from product of the original nonconforming ingot after additional discard. Should the latter specimen be unacceptable, resampling and retesting of the nonconforming ingot may be repeated after as many consecutive discards as necessary to obtain acceptable results. Should any of the adjacent ingot tests fail to meet the specified requirements, resampling and retesting of those ingots will be permitted using the procedure specified for the original nonconforming ingot.

##### Less than three ingots:

If there are less than three ingots in the heat, all tests locations that fail will be retested after discard is taken.

##### Strand cast heats:

One of the additional samples shall be taken from the section adjacent to the original nonconforming specimen after sufficient discard, and the two adjacent cuts (blooms) shall be sampled at both ends and tested. Should any of the adjacent cut (bloom) test locations fail to meet the specified requirements, resampling and retesting of those locations will be permitted using the procedure specified for the original nonconforming location.

