

NOTES:-

1. CAN BE MANUFACTURED IN 2 PIECES
2. MATL. FOR PART 2:- ASTM 106 G- B SEAMLESS TUBE
3. PART 1 DRG. AMENDED TO IS:513 EDD 606 CR4
4. R-4 OPEN TOLERANCE
5. GENERAL TOLERANCE IS:2102 TO BE APPLIED
6. PART 1 & PART 2 TO BE WELDED
7. AFTER WELDING WITH SILVER WASK (MS/72) PERFORM LEAK TEST AT 3 kg/cm² FOR 01 MINUTE TO BE UNDERT
8. CONCENTRICITY OF PT. 1 & PT. 2 TO BE MAINTAINED IN 0.1 MM
9. MATL. MANUFACTURED IN SINGLE PIECE. MATERIAL IS:513 EDD 606 CR4 IS TO BE USED
10. INTERMEDIATE STRESS RELIEVING TO BE CARRIED OUT AS PART OF DEEP DRAWING.
11. LINER TO BE HEAT TREATED AT TEMPERATURE 300±10 FOR TWO Hrs.

MARKING NOTES

THE FOLLOWING MARKINGS TO BE ENGRAVED IN 10 TO 20MM LETTER SIZE ON OUTSIDE SURFACE WITH CURVATURE R 180:-
 SERIAL NO. ☆ MANUFACTURE'S LOGO DEPTH OF ENGRAVING- 35 TO 75 MIC

5. 1009 810-2 MARKING NOTES AMENDED		SCALE IN TS		DIMENSIONS ARE IN mm		TOL		D.S.CAT N ₃		ASSY.DRG. No.NASK 1062(P)	
NO	DATE	ZONE	DRN	APPROVED	TCD	DRN	APPROVED	COMP.	CHD	ASSY.DRG.LIST No.	ASSY.DRG.LIST No.
5.	26-7-17	C/D-8	ARD 2532	✓	✓	ARD 2484	✓	IS:2102	IS:2102	IS:2102	IS:2102
4.	22-09-15		ARD 2484	✓	✓	ARD 2479	✓	IS:2102	IS:2102	IS:2102	IS:2102
3.	22-6-15	C/D-8	ARD 2479	✓	✓	ARD 2475	✓	IS:2102	IS:2102	IS:2102	IS:2102
2.	14-04-14		ARD 2413	✓	✓	ARD 2413	✓	IS:2102	IS:2102	IS:2102	IS:2102
1.	14-04-11		ARD 2413	✓	✓	ARD 2413	✓	IS:2102	IS:2102	IS:2102	IS:2102
	02-06-09		DGNAI	APPROVED		DGNAI	APPROVED	IS:2102	IS:2102	IS:2102	IS:2102
R.No	DATE	ZONE	AUTHORITY	INITIALS	PF	OTECTIVE FINISH. SEE ASSY DRG	SEE DRG	STORE SPEC. NO	GEN SPEC. IS:2102	THREADS TO CONFORM IS:4718	DTE GEN OF NAVAL
											ARMAMENT INSPECTION
											IHQ, MoD (NAVY), N DELHI



DRG No. **NASK 1062/3**
 (PROVISIONAL)

LINER

QUALITY ASSURANCE PLAN FOR A/S ROCKET RGB 60 (EMPTY) MOD 1

Item Description		LINER									
Ref. Document		NASK 1062/3 (P)									
Material		Part 1 : IS 513 EDD Gde CR4, Part 2 : ASTM A 106 Gde B seamless tube									
Component name/operations	Characteristics	Class	Type of check	Quantum of check	Reference document	Acceptance norms	Format of record	Inspection Activity Categorisation	Inspection by		
Liner (Raw material)	General finish, appearance	Semi critical	Visual	100%	ASTM A 106 Gde B & IS 513: EDD Gde CR4	ASTM A 106 Gde B & IS 513 EDD Gde CR4	Visual Inspn. Report	Critical	NAI		
	Chemical properties	Critical	Chemical lab analysis	Three samples per lot or as per the discretion of inspection authority			Test report from NABL Lab/ Govt lab				
	Mechanical properties	Critical	Mechanical lab analysis	Three samples per lot or as per the discretion of inspection authority			Test report from NABL Lab/ Govt lab				
In process -Sheet cutting, deep drawing, welding and turning	Dimensions	Critical	Dimensional measurement	100% or as per the discretion of inspection authority	Drg. NASK 1062/3 (P)	Tolerance as specified in Drg. NASK 1062/3 (P)	Inspection report				
Test	Leak test on assy with Sleeve at 3 kgf/cm ² for 1 min.	Critical	Visual	100%	As per relevant drg.	No leakage permitted					
	Phosphating	Non-Critical	Visual & as specified in specification.	100%	IS 3618 class B	IS 3618 class B					
Final finish(Post welding with Sleeve & Liner)	Varnishing APC 221 & APC 226	Non-Critical	Visual & as specified in specification.	100%	JSS 8010-63:2016 & JSS 8010-28:2015	As per spec.	Inspection report	Non-Critical	QC/ HEPF		
	Visual	Semi critical	Visual	100%	As per relevant drg.	As per relevant drg.					

Inspection Report

Description of the item	LINER
Drawing No.	NASK 1062/3(P)

Ser	Description of parameter	Nominal dimension as per drawing in mm	Gauge used	Tolerance (As per drg/ spec.)	Nature of parameter	Observed dimension in mm	Deviation in mm	Remarks
Liner Part - 1								
1	Overall length	35		±0.5	Minor			
2	Inner radius	R 180	Form gauge		Minor			
3	Inner radius	R 4			Minor			
4	Inner dimple dia.	25		±0.2	Major			
5	Outer dimple dia.	19			Major			
6	Outer dimple height	1.2		±0.2	Major			
7	Inner dimple height	1.8		±0.1	Major			
Liner Part-2								
1	Outer dia.	85		+0 /- 0.3	Major			
2	Inner dia.	81			Major			
Liner after joining Part-1&2								
1	Overall length	267			Minor			
2	Concentricity of part 1 & 2	Within 0.1 mm			Major			
3	Leak test	@ 3 kgf/cm ² for 1 min.			Major			

Special Notes:

Ser	Note	Observations
1	When manufactured in two pieces material for Part 1:- IS 513 EDD Gde CR4 and Part 2:- ASTM 106 A Gde B seamless tube.	
2	Part 1 and Part 2 to be welded & concentricity of liner part 1 & part 2 to be maintained within 0.1 mm.	
3	When manufactured in single piece material:- IS 513: Gde EDD Gr CR4	
4	(a) Intermediate stress relieving to be carried out as part of deep drawing.	
	(b) Heat Treatment of Liner at temperature 340°C ± 10°C for 2 Hrs.	
5	General Tolerance: IS 2102 (medium class) unless specified.	
6	After welding with Sleeve (NASK 1134/1/1/3 (P)), pneumatic leak test at 3 kgf /cm ² for 01 minute to be undertaken.	
7	R4 Open tolerance.	
8	Serial No. and Manufacturer's logo to be engraved in 10 to 20mm letter size on outer surface with curvature R180. Depth of engraving 35 to 75 microns.	

IS 513 : 2008

भारतीय मानक
अतप्त लघुकृत अल्प कार्बन इस्पात की चादर एवं पत्ती
(पाचँवा पुनरीक्षण)

Indian Standard
COLD REDUCED LOW CARBON STEEL
SHEET AND STRIP
(*Fifth Revision*)

ICS 77.140.50

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

April 2008

Price Group 5

AMENDMENT NO. 1 JULY 2010
TO
IS 513 : 2008 COLD REDUCED LOW CARBON STEEL SHEET AND STRIP
(Fifth Revision)

(Page 1, clause 3) — Insert 'CR0', before 'CR1'.

(Page 1, clause 4.3) — Substitute the following for the existing first para:

'Sheets and strips of CR2, CR3, CR4 and CR5 grade shall be supplied in annealed and skin passed condition. Grade CR0 shall be supplied in hard condition. Sheets and strips of CR1 grade may be supplied in any of the following condition:'

(Page 2, clause 5.2) — Substitute the following for the existing:

'CR0 and CR1 grade sheets and strips may be supplied rimmed, semi-killed, killed or as agreed between the purchaser and the manufacturer. However, other grades shall be supplied only in fully killed condition. CR4 and CR5 grade sheets and strips shall be supplied only in fully aluminium killed condition.'

(Page 2, Table 1) — Substitute the following for the existing:

Table 1 Chemical Composition
(Clauses 6.1 and 6.2)

SI No.	Quality		Constituent, Percent, Max			
	Designation	Name	Carbon	Manganese	Sulphur	Phosphorus
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	CR0	Hard	0.25	1.7	0.045	0.050
ii)	CR1	Commercial	0.15	0.60	0.040	0.050
iii)	CR2	Drawing	0.12	0.50	0.035	0.040
iv)	CR3	Deep Drawing	0.10	0.45	0.030	0.025
v)	CR4	Extra Deep Drawing Aluminium Killed (Non-ageing)	0.08	0.40	0.030	0.020
vi)	CR5	Extra Deep Drawing (Stabilized Interstitial Free)	0.06	0.25	0.020	0.020

NOTES

1 Restricted chemistry may be mutually agreed between the purchaser and the supplier.

2 When the steel is killed by aluminium alone the total aluminium content shall be 0.020 - 0.070 percent. When steel is silicon killed, the silicon content shall not be less than 0.1 percent. When the steel is aluminium-silicon killed, the silicon content shall not be less than 0.03 percent and total aluminium content shall not be less than 0.01 percent.

3 The nitrogen content of the steel shall not be more than 0.007 percent. However for CR0 and CR1, the nitrogen content shall not exceed 0.012 percent. This shall be ensured by the manufacturer by occasional check analysis.

4 The material may be supplied in the copper bearing quality in which case the copper shall be between 0.20 and 0.35 percent on ladle analysis. In case of product analysis, the copper content shall be permissible in between 0.17 and 0.38 percent.

5 The steel can be made with micro-alloying elements like niobium, vanadium, titanium and boron either individually or in combination, on mutual agreement in which case the total micro-alloying elements shall not exceed 0.2 percent in ladle analysis. However, in case of boron, the limit shall be 0.006 percent.

(Page 5, Table 3) — Substitute the following for the existing:

Table 3 Mechanical Properties at Room Temperature in as Delivered Condition
(Clauses 7.1.2, 7.1.5, 7.3, 7.5.2 and 7.6.2)

SI No.	Quality		Yield Stress R_c MPa	Tensile Strength R_m MPa	Elongation Percent, A, Min		Hardness Max		Bar, r Min	Bar, n Min
	Designation	Grade			$Lo = 80 mm$	$Lo = 50 mm$	HRB	HR(30T)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
i)	CR0	H	—	—	—	—	See Table 5		—	—
ii)	CR1	O	—	—	—	—	See Table 5		—	—
		340	260 <i>Min</i>	340 <i>Min</i>	26	29	—	—	—	—
		390	300 <i>Min</i>	390 <i>Min</i>	23	26	—	—	—	—
		440	350 <i>Min</i>	440 <i>Min</i>	20	23	—	—	—	—
iii)	CR2	D	240 <i>Max</i>	370 <i>Max</i>	30	31	65	60	—	—
iv)	CR3	DD	220 <i>Max</i>	350 <i>Max</i>	34	35	57	55	—	—
v)	CR4	EDD	210 <i>Max</i>	350 <i>Max</i>	36	37	50	50	—	—
vi)	CR5	IF	190 <i>Max</i>	350 <i>Max</i>	38	40	—	—	1.7	0.22
		IF340	125-225	340 <i>Min</i>	30	34	—	—	1.4	0.21
		IF390	165-245	390 <i>Min</i>	27	31	—	—	1.3	0.2
		IF440	185-295	440 <i>Min</i>	24	28	—	—	1.2	0.19
		BH270	225-345	270 <i>Min</i>	31	35	—	—	1.4	0.21
		BH320	150-200	320 <i>Min</i>	28	32	—	—	1.3	0.2
		BH370	180-250	370 <i>Min</i>	25	29	—	—	1.2	0.19

NOTES

1 1 MPa = 1 N/mm² = 1 MN/m² = 0.102 0 kgf/mm².

2 For materials up to and including 0.6 mm in thickness, the elongation values in the table shall be reduced by 1.

3 Equivalent Vickers hardness values are allowed on agreement between the interested parties at the time of ordering. The hardness of sheet thinner than 0.6 mm shall be measured exclusively in compliance with the HR 30T scale.

4 Mechanical properties are not generally done on Commercial Quality Products and the values in this table are for information only.

5 For CR4 Grade, Bar r can be given based on mutual agreement between the purchaser and the supplier.

(Page 6, Table 5, Title) — Insert 'CR0 and' before 'CR1'.

(Page 6, Table 6, Row 1) — Delete.

(Page 7, Table 7, Title) — Insert 'CR0 and' before 'CR1'.

(MTD 4)

FOREWORD

This Indian Standard (Fifth Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Wrought Steel Products Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard was first published in 1954 and revised in 1963, 1973, 1986 and 1994. While reviewing this standard, in the light of experience gained during these years, the Committee decided to revise it to bring in line with the present manufacturing and trade practices being followed in the country in this field.

In the present revision, the following modifications have been made:

- a) ISO designations have been adopted,
- b) Table 1 and Table 3 have been modified,
- c) New grade CR5 Extra Deep Drawing (stabilized interstitial free) has been added,
- d) Correlation of old designations with new designations has been given for information (*see* Annex A),
- e) A new clause on references has been incorporated,
- f) Amendments No. 1 and 2 have been incorporated,
- g) IS 8910 : 1978 has been adopted for general technical delivery requirements,
- h) Clause on retest has been modified,
- j) Values for plastic anisotropy (r) and strain hardening exponent (n) have been incorporated,
- k) Applicable period for mechanical and physical properties has been included,
- m) Requirements of dimensional and shape tolerances have been separated from the standard and adopted IS/ISO 16162 : 2005 'Continuously cold-rolled steel sheet products — Dimensional and shape tolerances', and
- n) A clause for alternate test method specified in relevant ISO/IEC Standard has been added.

Assistance has been derived from the following:

ISO 3574 : 1999	Cold-reduced carbon steel sheet of commercial and drawing qualities
BS EN 10130 : 1991	Cold rolled low carbon steel flat products for cold forming: Technical delivery conditions

The composition of the Committee responsible for formulation of this standard is given in Annex C.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

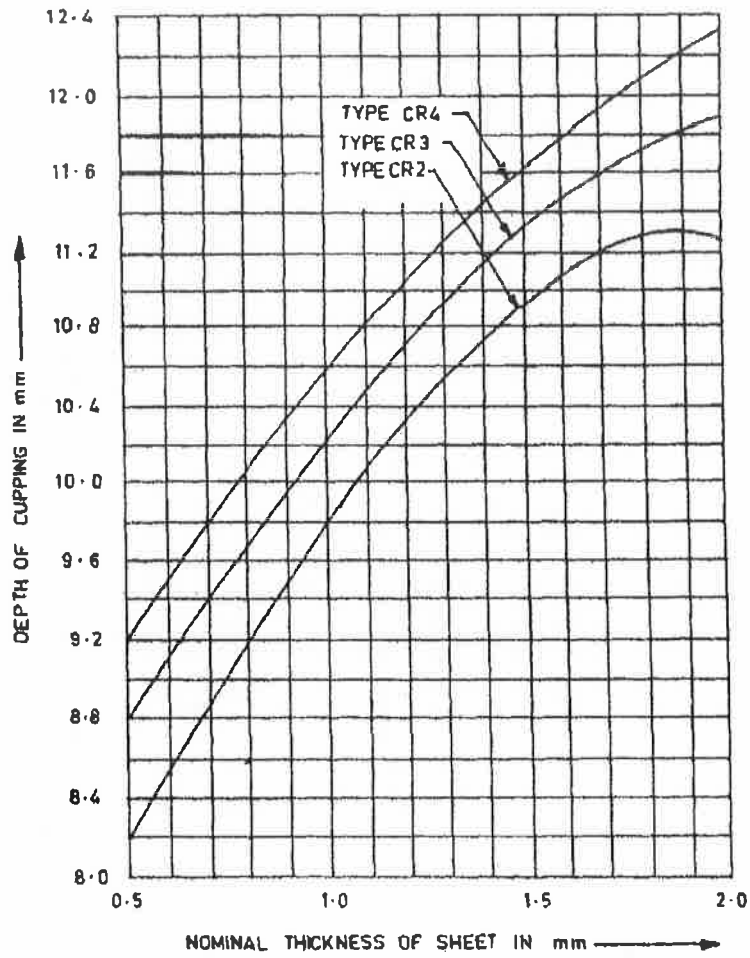


FIG. 1 MINIMUM ERICHSON VALUES

Indian Standard
**COLD REDUCED LOW CARBON STEEL
 SHEET AND STRIP**
(Fifth Revision)

1 SCOPE

This standard covers the requirements of cold reduced low carbon steel sheets and strips for bending and drawing purpose and where the surface is of prime importance. It covers sheets and strips up to 4.50 mm thick, both in coil form and cut lengths.

2 REFERENCES

The following standards contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

<i>IS No.</i>	<i>Title</i>
228 (Relevant Parts)	Method for chemical analysis of steel
1501 : 2000/ ISO 6507-1 : 1997	Method for Vickers hardness test for metallic material (<i>third revision</i>)
1586 : 2000	Method for Rockwell hardness test for metallic material (Scales A-B-C-D-E-F-G-H-K) (<i>third revision</i>)
1599 : 1985	Method for bend test (<i>second revision</i>)
1608 : 2005/ ISO 6892 : 1998	Metallic materials — Tensile testing at ambient temperature (<i>third revision</i>)
8910 : 1978	General technical delivery requirements for steel and steel products
10175 (Part 1) : 1993	Mechanical testing of metals — Modified Erichson cupping test — Sheet and strip: Part 1 Thickness up to 2 mm (<i>first revision</i>)
11999 : 1987	Method for determination of plastic strain ratio 'r' for steel sheets
15756 : 2007/ ISO 10275 : 1993	Metallic materials — Sheet and strip — Determination of tensile strain hardening exponent
IS/ISO 16162 : 2005	Continuously cold-rolled steel sheet products — Dimensional and shape tolerances

3 CLASSIFICATION OF GRADES

Sheets and strips shall be classified in the CR1, CR2, CR3, CR4 and CR5 grades/designations.

4 SUPPLY OF MATERIAL

4.1 General requirements relating to the supply of cold rolled low carbon steel sheets and strips shall conform to IS 8910.

4.2 Sheets and strips may be supplied either with mill or trimmed edges.

4.3 Sheets and strips of CR1 grade may be supplied in any of following tempers. Sheets and strips of CR2, CR3, CR4 and CR5 grade shall be supplied in annealed and skin-passed condition:

<i>Temper Designation</i>	<i>Temper</i>	<i>Processing</i>
H	Hard	Produced by heavy cold rolling
1/2H	Half Hard	Produced by cold rolling followed by annealing and further cold rolling to give strip of intermediate hardness
1/4H	Quarter Hard	do
SP	Skin Passed	Produced by light cold rolling after annealing
A	Annealed	Produced by a final annealing process

For specific applications, sheets and strips may also be supplied in any other temper subject to agreement between the supplier and the purchaser.

4.4 Non-ageing Characteristics

4.4.1 The manufacturer shall guarantee the absence of stretcher strains on being cold worked in the case of non-ageing quality with a non-ageing guarantee for six months from the date of dispatch.

4.4.2 CR4 and CR5 grade sheets and strips shall be supplied only in non-ageing quality with a non-ageing guarantee for six months from the date of dispatch.

IS 513 : 2008

4.4.3 A stability test as per Annex B may be carried out to assess the non-ageing characteristics of skin passed stabilized steels with mutual agreement between the manufacturer and the purchaser.

4.4.3.1 The steel shall be considered stabilized if the percentage increase in load does not exceed 6 when tested as per Annex B.

5 MANUFACTURE

5.1 The method of manufacture of the steel for sheets and strips shall be left at the discretion of the manufacturer.

5.2 Sheets and strips shall be supplied rimmed, semi-killed or killed as agreed between the purchaser and the manufacturer. However, CR4 and CR5 grades shall be supplied only in fully aluminium killed or in a fully stabilized condition.

6 CHEMICAL COMPOSITION

6.1 Ladle Analysis

The ladle analysis of steel, when carried out either by

the methods specified in relevant parts of IS 228 or any other established instrumental/chemical method, shall be as given in Table 1. In case of any dispute, the procedure given in relevant parts of IS 228 shall be the referee method.

6.1.1 Alternatively, the method specified in relevant ISO/IEC standard may be used.

6.2 Product Analysis

Permissible variation in the case of product analysis from the limits specified in Table 1 shall be as given in Table 2.

7 MECHANICAL AND PHYSICAL PROPERTIES

7.1 Tensile Test

7.1.1 Tensile test shall be carried out only, if specified by the purchaser.

7.1.2 When specified, the tensile test shall be carried out in accordance with IS 1608 as applicable, and the values of tensile strength, yield stress and percentage

Table 1 Chemical Composition
(Clauses 6.1 and 6.2)

Sl No.	Quality		Constituent, Percent, Max				
	Designation	Name	Carbon	Manganese	Sulphur	Phosphorus	Titanium
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	CR1	Commercial	0.15	0.60	0.035	0.050	—
ii)	CR2	Drawing	0.12	0.50	0.035	0.040	—
iii)	CR3	Deep Drawing	0.10	0.45	0.030	0.025	—
iv)	CR4	Extra Deep Drawing Aluminium Killed (Non-ageing)	0.08	0.40	0.030	0.020	—
v)	CR5	Extra Deep Drawing (Stabilized Interstitial Free)	0.06	0.25	0.020	0.020	0.15

NOTES

- 1 Restricted chemistry for CR4 and CR5 grade may be mutually agreed between the purchaser and the supplier.
- 2 When the steel is killed by aluminium alone the total aluminium content should be 0.020-0.070 percent. When steel is silicon killed, the silicon content shall not be less than 0.1 percent. When the steel is aluminium-silicon killed, the silicon content shall not be less than 0.03 percent and total aluminium content shall not be less than 0.01 percent.
- 3 The nitrogen content of the steel shall not be more than 0.007 percent. However for CR1, the nitrogen content shall not exceed 0.012 percent. This shall be ensured by the manufacturer by occasional check analysis.
- 4 The material may be supplied in the copper bearing quality in which case the copper shall be between 0.20 and 0.35 percent on ladle analysis. In case of product analysis, the copper content shall be permissible in between 0.17 and 0.38 percent.
- 5 The steel can be made with micro-alloying elements like niobium, vanadium, titanium and boron either individually or in combination, on mutual agreement in which case the total micro-alloying elements should not exceed 0.2 percent in ladle analysis. However, in case of boron, the limit shall be 0.006 percent.
- 6 The titanium may be replaced totally or partially by niobium or vanadium and may be completely stabilized.

Table 2 Permissible Variation for Product Analysis
(Clause 6.2)

Sl No.	Constituent	Variation Over Specified Limit Percent, Max
(1)	(2)	(3)
i)	Carbon	0.02
ii)	Manganese	0.03
iii)	Sulphur	0.005
iv)	Phosphorus	0.005

NOTE — Product analysis shall not be applicable to rimming steel.

elongation shall conform to the requirements specified in Table 3.

7.1.3 Tensile test values apply to transverse specimen in case of sheet/strips. Strips having a width of 250 mm and below shall be tested longitudinally.

7.1.4 The yield strength values apply to the 0.2 percent proof stress, if the yield strength is not clearly distinctive, otherwise the values apply to lower yield strength.

7.1.5 The values specified in Table 3 are applicable for the period indicated in Table 4 from the time that the steel is available for shipment.

7.2 Cupping Test

7.2.1 Cupping test shall be applicable only for sheets, strips and coils of CR2, CR3 and CR4 grades having thickness from 0.5 mm up to 2.00 mm.

7.2.2 Cupping test shall be carried out in accordance with IS 10175 (Part 1), and the minimum Erichson cupping test values shall be as given in Fig. 1.

NOTE — The shape of the cup fracture may be as mutually agreed between the purchaser and the supplier.

7.3 Hardness Test

Cold rolled sheets and strips shall conform to the hardness requirements specified in Table 3 and Table 5, when tested in accordance with IS 1586 and IS 1501 as applicable. However, by way of departure from these standards, a visible deformation on the back side of the specimen is permitted. The values determined in this way shall be identified by using symbols HRBm and HR30Tm, so as to differentiate these from the hardness values determined on thicker products (which are not allowed to exhibit a visible deformation on the back side of the specimen).

7.4 Bend Test

7.4.1 Bend test shall be carried out in accordance with IS 1599.

7.4.2 The angle of bend and the internal diameter of the bend for the different grades of material shall be as given in Tables 6 and 7. The axis of the bend shall be in the direction of rolling. The test pieces shall be deemed to have passed the test if the outer convex surface is free from cracks.

7.5 Plastic Strain Ratio, r

7.5.1 The plastic strain ratio is an index of drawability (r), shall be applicable only to thicknesses between 0.5 to 2.0 mm. For thicknesses more than 2.0 mm, the r value is reduced by 0.2.

7.5.2 The plastic strain ratio shall be checked in accordance with IS 11999, and the minimum r value shall be as given in Table 3.

7.6 Tensile Strain Hardening Component, n

7.6.1 The tensile strain hardening component is an index of the stretchability (n), shall be applicable only to thicknesses between 0.5 mm and 2.0 mm. For thicknesses more than 2.0 mm the n value is reduced by 0.02.

7.6.2 The tensile strain hardening component shall be checked in accordance with IS 15756 and the minimum n value shall be as given in Table 3.

7.7 Retest

If a test does not give the specified results, two additional tests shall be carried out at random on the same lot. Both retests shall conform to the requirements of this standard, otherwise, the lot shall be rejected.

8 SURFACE FINISH

8.1 Cold-Reduced Steel Sheet

This product is normally supplied skin passed (see 8.2) but may be supplied annealed last (that is without a skin pass), if specified by the purchaser on his order.

8.2 Skin Pass

The purpose of skin passing is one or more of the following:

- To temporarily minimize the appearance of coil breaks, stretcher strains (Luders lines) or fluting during fabrication of finished parts,
- To obtain the required surface finish suitable for ordinary decorative painting, and
- To control the shape.

Some increase in hardness and some loss in ductility will result from skin passing.

8.3 Strain Ageing

Cold reduced sheet in qualities CR1, CR2 and CR3

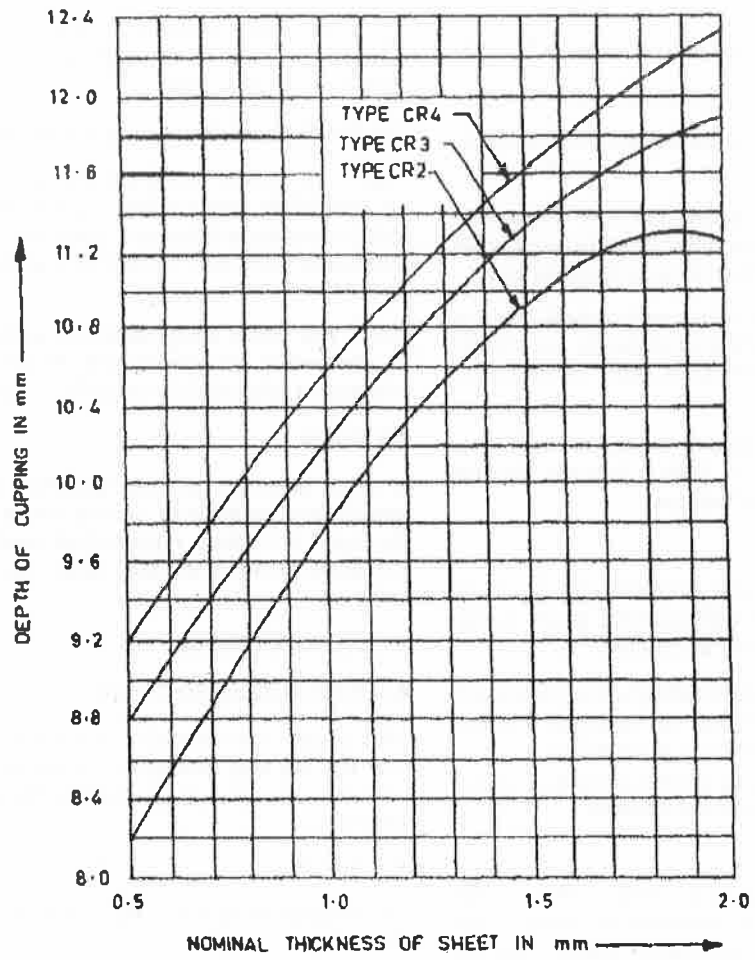


FIG. 1 MINIMUM ERICHSON VALUES

Table 3 Mechanical Properties at Room Temperature in as Delivered Condition for Annealed/Skin Passed Sheets and Strips (Cut Lengths and Coils)

(Clauses 7.1.2, 7.1.5, 7.3, 7.5.2 and 7.6.2)

Sl No.	Quality		Yield Stress R_p MPa	Tensile Strength R_m MPa	Elongation Percent <i>A</i> <i>Min</i>		Hardness <i>Max</i>		<i>r</i> -Bar <i>Min</i>	<i>n</i> -Bar <i>Min</i>	
	Designation	Name			<i>Max</i>	$L_{0.2} = 80$ mm	$L_{0.2} = 50$ mm	HRB			HR (30T)
i)	CR1	Commercial	280	410	27	28	See Table 4		-	-	
ii)	CR2	Drawing	240	370	30	31	65	60	-	-	
iii)	CR3	Deep Drawing	220	350	34	35	57	55	-	-	
iv)	CR4	Extra Deep Drawing Aluminium Killed (Non-ageing)	210	350	36	37	50	50	-	-	
v)	CR5	Extra Deep Drawing (Stabilized Interstitial Free)	190	350	38	40	-	-	1.7	0.22	

NOTES

- 1 MPa = 1 N/mm² = 1 MN/m² = 0.102 0 kgf/mm².
- 2 The minimum tensile strength for qualities CR2, CR3 and CR4 would normally be expected to be 270 MPa. All tensile strength values are determined to the nearest 10 MPa. For designing purposes, the lower limit for R_p may be assumed to be 140 MPa for grades CR1, CR2, CR3 and CR4 and 120 MPa for grade CR5.
- 3 For materials up to and including 0.6 mm in thickness, the elongation values in the table shall be reduced by 1.
- 4 Equivalent Vickers hardness values are allowed on agreement between the interested parties at the time of ordering. The hardness of sheet thinner than 0.6 mm shall be measured exclusively in compliance with the HR 30T scale.
- 5 Mechanical properties are not generally done on Commercial Quality Products and the values in this table are for information only.
- 6 For CR4 Grade *r* bar value can be given based on mutual agreement between the purchaser and the supplier.

supplied in the skin-passed condition tends to strain-age and this may lead to the following:

- a) Surface markings from stretcher strains (Luders lines) or fluting when the steel is formed, and
- b) Deterioration in ductility.

Because of these factors, it is essential that the period between final processing at the mill and fabrication be kept to a minimum. Rotation of stock, by using the oldest material first, is important. Stocking of such steels for extended periods of time should be avoided; for optimum performance the period should not exceed six weeks.

For skin-passed sheet in qualities CR1, CR2 and CR3 and with due regard to the foregoing precautions, reasonable freedom can be achieved by effective roller levelling immediately prior to fabrication at the purchaser's plant. Freedom from stretcher strain and fluting for a period of six months can be achieved by the supply of skin-passed non-ageing steels. Grades CR4 or CR5 shall be specified in such cases where

Luder's lines are not acceptable and where roller levelling is not possible.

8.4 Surface Condition

8.4.1 The condition of the surface of cold-reduced steel sheet of drawing qualities (CR2, CR3, CR4 and CR5) is not required to be same for unexposed parts as it is for exposed parts.

8.4.2 Surface condition of sheet for unexposed parts may contain pores, some slight pitting, small markings, scratches, other minor defects and a light discoloration. The surface of sheet for exposed parts shall be reasonably free of these conditions. Unless otherwise agreed, only one side is inspected.

8.5 Surface Finish

8.5.1 Cold-reduced steel sheet may be supplied in a smooth finish and matt finish, dull in appearance, which is suitable for ordinary decorative painting but is not recommended for electroplating. Surface

Table 4 Applicable Period for Values Specified in Table 3

(Clause 7.1.5)

Sl No.	Designation	Period
(1)	(2)	(3)
i)	CR2	8 days
ii)	CR3	8 days
iii)	CR4	6 months
iv)	CR5	6 months

Table 5 Hardness of Different Tempers at Room Temperature for CR1 Grade

(Clause 7.3)

Sl No.	Temper	Hardness HRB	
		Min	Max
(1)	(2)	(3)	(4)
i)	Hard (H)	85	-
ii)	Half Hard (1/2 H)	75	85
iii)	Quarter Hard (1/4 Hard)	60	75
iv)	Skin Passed (SP)	-	70
v)	Annealed (A) (Dead Soft)	-	68

NOTES

1 For tempers other than those mentioned in this table, the values shall be as agreed to between the contracting parties.

2 Equivalent Vickers hardness values are allowed on agreement between the interested parties at the time of ordering. The hardness of sheet thinner than 0.6 mm shall be measured exclusively in compliance with the HR30T scales.

Table 6 Bend Test for Sheets/Strips in Cut Lengths and Coils in Annealed and Skin Pass Condition

(Clause 7.4.2)

Sl No.	Steel Grade	Angle of Bend Degree	Internal Diameter of Bend
(1)	(2)	(3)	(4)
i)	CR1	180	/
ii)	CR2	180	Close
iii)	CR3	180	Close
iv)	CR4	180	Close
v)	CR5	180	Close

Where / is the thickness of test piece.

roughness value μ_{ra} may be given subject to mutual agreement between the supplier and the purchaser.

8.5.2 When cold-reduced steel sheet is deformed during fabrication, localized areas may roughen to some degree and such affected portions of the part may require hand finishing to prepare the surface for the intended application.

8.6 Oiling

As a deterrent to rusting, a coating of oil is usually applied to the product. The oil is not intended as a drawing or forming lubricant and should be easily removable with degreasing chemicals. The product may be ordered not oiled, if required, in which case, the supplier has limited responsibility, if oxidation occurs.

9 FREEDOM FROM DEFECTS

9.1 The finished sheets and strips shall be free from harmful defects, such as scale, rust, blisters, lamination, pitting, porosity, cracked or torn edges or any other defects which are harmful to the intended use.

9.2 The degree or amount of surface defects in a coil may be expected to be more than in cut lengths because of the impossibility of rejecting portions of a coil. This shall be taken into account by the purchaser in his assessment of the material. An excessive amount of defects may be a cause for rejection.

9.3 The sheets shall be reasonably flat and edges cleanly sheared and squared to the specified dimensions.

10 DIMENSIONS AND TOLERANCES

10.1 Unless otherwise agreed to between the manufacturer and the purchaser, standard dimensions of cold rolled sheets and strips shall be as given below:

Thickness, mm = 0.18, 0.20, 0.22, 0.25, 0.28, 0.30, 0.32, 0.35, 0.40, 0.45, 0.50, 0.55, 0.63, 0.70, 0.80, 0.90, 1.00, 1.20, 1.25, 1.40, 1.50, 1.60, 1.80, and 2.00.

The following are the preferred thicknesses for sheets above 2.00 mm:

2.50 mm, 2.65 mm, 3.00 mm, 3.25 mm, 3.50 mm, and 4.00 mm.

10.2 Unless otherwise specified, the dimensional and shape tolerances applicable to cold rolled sheets and strips shall be as given in IS/ISO 16162 : 2005.

11 SAMPLING FOR TESTS

11.1 One representative sample from a coil or a lot of sheets shall be taken for tensile testing. A lot consists of 50 tonnes or less of sheets or strips of the same quality

Table 7 Bend Test for Sheets/Strips of 'CR1' Grade

(Clause 7.4.2)

Sl No.	Steel Grade	Angle of Bend Degree	Internal Diameter of Bend
(1)	(2)	(3)	(4)
i)	Hard (H)	—	—
ii)	Half Hard (1/2 H)	180	3 t
iii)	Quarter Hard (1/4 Hard)	180	2 t
iv)	Skin Passed (SP)	180	t
v)	Annealed (A) (Dead Soft)	180	t

Where t is the thickness of test piece.

rolled to the same thickness and condition. If the lot consists of more than one heat, samples from each heat shall be tested.

11.2 For cupping, hardness and bend tests, one sample from each lot of 50 tonnes of the same heat or part thereof or one sample from each coil shall be taken.

11.2.1 The specimens shall not undergo any treatment on either surface before testing. In the case of coils, samples shall be taken from the beginning or end of the coil.

12 MARKING

12.1 The following shall be legibly marked on the top of each bundle of package of sheets or shown on a tag attached to each coil:

- Manufacturer's name or trade-mark,
- Quality designation,
- Product dimensions,
- Cast or identification mark by which the sheet or strip may be traced to cast or casts from which they were made,
- Mass/Net weight, and
- Date of dispatch.

12.2 BIS Certification Marking

The material may also be marked with the Standard Mark.

12.2.1 The use of the Standard Mark is governed by the provisions of *Bureau of Indian Standards Act, 1986* and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

12.3 Packing

12.3.1 Each sheet shall be treated on both sides with non-hardening type rust preventive oil, which can be easily washed with aqueous alkali solution.

12.3.2 Sheets and strips shall preferably be supplied in bundles or packages not weighing more than 3 tonnes or as agreed to between the purchaser and the manufacturer.

12.3.3 Sheets and strips shall be securely packed in waterproof material and covered all over with steel envelope and securely tied round with steel straps and preferably with wooden battens underneath to prevent the sheets from rusting and damage during transit.

ANNEX A

(Foreword)

CORRELATION OF OLD AND NEW GRADES/DESIGNATIONS

<i>Old Designation</i>		<i>New Designation</i>	
Designation	Name	Designation	Name
O	Ordinary quality	CR1	Commercial
D	Drawn quality	CR2	Drawing
DD	Deep drawn quality	CR3	Deep drawing
EDD	Extra deep drawn quality	CR4	Extra deep drawing Aluminium killed (Non-ageing)
		CR5 (New grade added)	Extra deep drawing (Stabilized interstitial free)

ANNEX B

(Clauses 4.4.3 and 4.4.3.1)

STABILITY TEST

B-1 A tensile test piece shall be subjected to a total strain of 10 percent and the load (P_1) required to produce this strain shall be noted. The test piece shall then be subjected to an accelerated ageing treatment by heating at a nominal temperature of 100°C for 30 min. The test piece shall thereafter again be strained to 10 percent, calculated on the original (unstrained)

gauge length, and the load (P_2) noted.

The steel shall be considered stabilized, if the percentage increase in load = $\frac{P_2 - P_1}{P_1} \times 100$ does not exceed 6.



Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service¹

This standard is issued under the fixed designation A 106/A 106M; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This specification² covers seamless carbon steel pipe for high-temperature service (Note 1) in NPS 1/8 to NPS 48 [DN 6 to DN 1200] (Note 2) inclusive, with nominal (average) wall thickness as given in ASME B 36.10M. It shall be permissible to furnish pipe having other dimensions provided such pipe complies with all other requirements of this specification. Pipe ordered under this specification shall be suitable for bending, flanging, and similar forming operations, and for welding. When the steel is to be welded, it is presupposed that a welding procedure suitable to the grade of steel and intended use or service will be utilized.

NOTE 1—It is suggested, consideration be given to possible graphitization.

NOTE 2—The dimensionless designator NPS (nominal pipe size) [DN (diameter nominal)] has been substituted in this standard for such traditional terms as “nominal diameter,” “size,” and “nominal size.”

1.2 Supplementary requirements of an optional nature are provided for seamless pipe intended for use in applications where a superior grade of pipe is required. These supplementary requirements call for additional tests to be made and when desired shall be so stated in the order.

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 is to be used independently of the other.

1.4 The following precautionary caveat pertains only to the test method portion, Sections 11, 12, 13, 14, and 15, of this specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

¹ This specification is under the jurisdiction of Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.09 on Carbon Steel Tubular Products.

Current edition approved Oct. 1, 2004. Published October 2004. Originally approved in 1926. Last previous edition in 2004 as A 106/A 106M – 04a.

² For ASME Boiler and Pressure Vessel Code applications see related Specifications SA-106 in Section II of that Code.

2. Referenced Documents

2.1 ASTM Standards:³

A 530/A 530M Specification for General Requirements for Specialized Carbon and Alloy Steel Pipe

E 213 Practice for Ultrasonic Examination of Metal Pipe and Tubing

E 309 Practice for Eddy-Current Examination of Steel Tubular Products Using Magnetic Saturation

E 381 Method of Macroetch Testing Steel Bars, Billets, Blooms, and Forgings

E 570 Practice for Flux Leakage Examination of Ferromagnetic Steel Tubular Products

2.2 ASME Standard:

ASME B 36.10M Welded and Seamless Wrought Steel Pipe⁴

2.3 Military Standards:

MIL-STD-129 Marking for Shipment and Storage⁵

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage⁵

2.4 Federal Standard:

Fed. Std. No. 123 Marking for Shipments (Civil Agencies)⁵

Fed. Std. No. 183 Continuous Identification Marking of Iron and Steel Products⁵

2.5 Other Standards:

SSPC-SP 6 Surface Preparation Specification No. 6⁶

3. Ordering Information

3.1 The inclusion of the following, as required will describe the desired material adequately, when ordered under this specification:

3.1.1 Quantity (feet, metres, or number of lengths),

³ 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.

⁴ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990.

⁵ Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098.

⁶ Available from Steel Structures Painting Council (SSPC), 40 24th St., 6th Floor, Pittsburgh, PA 15222-4656.

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

- 3.1.2 Name of material (seamless carbon steel pipe),
- 3.1.3 Grade (Table 1),
- 3.1.4 Manufacture (hot-finished or cold-drawn),
- 3.1.5 Size (NPS [DN] and weight class or schedule number, or both; outside diameter and nominal wall thickness; or inside diameter and nominal wall thickness),
- 3.1.6 Special outside diameter tolerance pipe (16.2.2),
- 3.1.7 Inside diameter tolerance pipe, over 10 in. [250 mm] ID (16.2.3),
- 3.1.8 Length (specific or random, Section 20),
- 3.1.9 Optional requirements (Section 9 and S1 to S8),
- 3.1.10 Test report required (Section on Certification of Specification A 530/A 530M),
- 3.1.11 Specification designation (A 106 or A 106M, including year-date),
- 3.1.12 End use of material,
- 3.1.13 Hydrostatic test in accordance with Specification A 530/A 530M or 13.3 of this specification, or NDE in accordance with Section 14 of this specification.
- 3.1.14 Special requirements.

4. Process

4.1 The steel shall be killed steel, with the primary melting process being open-hearth, basic-oxygen, or electric-furnace, possibly combined with separate degassing or refining. If secondary melting, using electroslag remelting or vacuum-arc remelting is subsequently employed, the heat shall be defined as all of the ingots remelted from a single primary heat.

4.2 Steel cast in ingots or strand cast is permissible. When steels of different grades are sequentially strand cast, identification of the resultant transition material is required. The producer shall remove the transition material by any established procedure that positively separates the grades.

4.3 For pipe NPS 1½ [DN 40] and under, it shall be permissible to furnish hot finished or cold drawn.

4.4 Unless otherwise specified, pipe NPS 2 [DN 50] and over shall be furnished hot finished. When agreed upon between the manufacturer and the purchaser, it is permissible to furnish cold-drawn pipe.

5. Heat Treatment

5.1 Hot-finished pipe need not be heat treated. Cold-drawn pipe shall be heat treated after the final cold draw pass at a temperature of 1200 °F (650 °C) or higher.

TABLE 1 Chemical Requirements

	Composition, %		
	Grade A	Grade B	Grade C
Carbon, max ^A	0.25	0.30	0.35
Manganese	0.27–0.93	0.29–1.06	0.29–1.06
Phosphorus, max	0.035	0.035	0.035
Sulfur, max	0.035	0.035	0.035
Silicon, min	0.10	0.10	0.10
Chrome, max ^B	0.40	0.40	0.40
Copper, max ^B	0.40	0.40	0.40
Molybdenum, max ^B	0.15	0.15	0.15
Nickel, max ^B	0.40	0.40	0.40
Vanadium, max ^B	0.08	0.08	0.08

^A For each reduction of 0.01 % below the specified carbon maximum, an increase of 0.06 % manganese above the specified maximum will be permitted up to a maximum of 1.35 %.

^B These five elements combined shall not exceed 1 %.

6. General Requirements

6.1 Material furnished to this specification shall conform to the applicable requirements of the current edition of Specification A 530/A 530M unless otherwise provided herein.

7. Chemical Composition

7.1 The steel shall conform to the requirements as to chemical composition prescribed in Table 1.

8. Heat Analysis

8.1 An analysis of each heat of steel shall be made by the steel manufacturer to determine the percentages of the elements specified in Section 7. If the secondary melting processes of 5.1 are employed, the heat analysis shall be obtained from one remelted ingot or the product of one remelted ingot of each primary melt. The chemical composition thus determined, or that determined from a product analysis made by the manufacturer, if the latter has not manufactured the steel, shall be reported to the purchaser or the purchaser's representative, and shall conform to the requirements specified in Section 7.

9. Product Analysis

9.1 At the request of the purchaser, analyses of two pipes from each lot (Note 3) of 400 lengths or fraction thereof, of each size up to, but not including, NPS 6 [DN 150], and from each lot of 200 lengths or fraction thereof of each size NPS 6 [DN 150] and over, shall be made by the manufacturer from the finished pipe. The results of these analyses shall be reported to the purchaser or the purchaser's representative and shall conform to the requirements specified in Section 7.

9.2 If the analysis of one of the tests specified in 9.1 does not conform to the requirements specified in Section 7, analyses shall be made on additional pipes of double the original number from the same lot, each of which shall conform to requirements specified.

NOTE 3—A lot shall consist of the number of lengths specified in Sections 9 and 21 of the same size and wall thickness from any one heat of steel.

10. Tensile Requirements

10.1 The material shall conform to the requirements as to tensile properties given in Table 2.

11. Bending Requirements

11.1 For pipe NPS 2 [DN 50] and under, a sufficient length of pipe shall stand being bent cold through 90° around a cylindrical mandrel, the diameter of which is twelve times the outside diameter (as shown in ASME B 36.10M) of the pipe, without developing cracks. When ordered for close coiling, the pipe shall stand being bent cold through 180° around a cylindrical mandrel, the diameter of which is eight times the outside diameter (as shown in ASME B 36.10M) of the pipe, without failure.

11.2 Subject to the approval of the purchaser, for pipe whose diameter exceeds 10 in. [250 mm], it shall be permissible for the bend test to be substituted for the flattening test described in Section 12. The bend test specimens shall be bent at room temperature through 180° with the inside diameter of

TABLE 2 Tensile Requirements

	Grade A		Grade B		Grade C	
	Longitudinal	Transverse	Longitudinal	Transverse	Longitudinal	Transverse
Tensile strength, min, psi [MPa]	48 000 [330]		60 000 [415]		70 000 [485]	
Yield strength, min, psi [MPa]	30 000 [205]		35 000 [240]		40 000 [275]	
Elongation in 2 in. [50 mm], min, %:						
Basic minimum elongation transverse strip tests, and for all small sizes tested in full section	35	25	30	16.5	30	16.5
When standard round 2-in. [50-mm] gage length test specimen is used	28	20	22	12	20	12
For longitudinal strip tests	A		A		A	
For transverse strip tests, a deduction for each 1/32-in. [0.8-mm] decrease in wall thickness below 3/16 in. [7.9 mm] from the basic minimum elongation of the following percentage shall be made		1.25		1.00		1.00

^A The minimum elongation in 2 in. [50 mm] shall be determined by the following equation:

$$e = 625\ 000A^{0.2} / U^{0.9}$$

for SI units, and

$$e = 1\ 940A^{0.2} / U^{0.9}$$

for Inch-pound units,

where:
e = minimum elongation in 2 in. [50 mm], %, rounded to the nearest 0.5 %,
A = cross-sectional area of the tension test specimen, in.² [mm²], based upon specified outside diameter or nominal specimen width and specified wall thickness, rounded to the nearest 0.01 in.² [1 mm²]. (If the area thus calculated is equal to or greater than 0.75 in.² [500 mm²], then the value 0.75 in.² [500 mm²] shall be used.), and
U = specified tensile strength, psi [MPa].

the bend being 1 in. [25 mm], without cracking on the outside portion of the bent portion.

11.3 For pipe whose diameter exceeds 25 in. [635 mm] and whose diameter to wall thickness ratio is 7.0 or less, the bend test described in 11.2 shall be conducted instead of the flattening test.

NOTE 4—Diameter to wall thickness ratio = specified outside diameter/nominal wall thickness.

Example: For 28 in. [711 mm] diameter 5.000 in. [127 mm] thick pipe the diameter to wall thickness ratio = 28/5 = 5.6 [711/127 = 5.6].

12. Flattening Tests

12.1 Except as allowed by 11.2, for pipe over NPS 2 [DN 0], a section of pipe not less than 2½ in. [63.5 mm] in length shall be flattened cold between parallel plates until the opposite walls of the pipe meet. Flattening tests shall be in accordance with Specification A 530/A 530M, except that in the formula used to calculate the “*H*” value, the following “*e*” constants shall be used:

0.08 for Grade A
 0.07 for Grades B and C

12.2 When low *D*-to-*t* ratio tubulars are tested, because the strain imposed due to geometry is unreasonably high on the inside surface at the six and twelve o'clock locations, cracks at these locations shall not be cause for rejection if the *D*-to-*t* ratio is less than ten.

13. Hydrostatic Test

13.1 Except as allowed by 13.2, 13.3, and 13.4, each length of pipe shall be subjected to the hydrostatic test without leakage through the pipe wall.

13.2 As an alternative to the hydrostatic test at the option of the manufacturer or where specified in the purchase order, it

shall be permissible for the full body of each pipe to be tested with a nondestructive electric test described in Section 14.

13.3 Where specified in the purchase order, it shall be permissible for pipe to be furnished without the hydrostatic test and without the nondestructive electric test in Section 14; in this case, each length so furnished shall include the mandatory marking of the letters “NH.” It shall be permissible for pipe meeting the requirements of 13.1 or 13.2 to be furnished where pipe without either the hydrostatic or nondestructive electric test has been specified in the purchase order; in this case, such pipe need not be marked with the letters “NH.” Pipe that has failed either the hydrostatic test of 13.1 or the nondestructive electric test of 13.2 shall not be furnished as “NH” pipe.

13.4 Where the hydrostatic test and the nondestructive electric test are omitted and the lengths marked with the letters “NH,” the certification, where required, shall clearly state “Not Hydrostatically Tested,” and the letters “NH” shall be appended to the product specification number and material grade shown on the certification.

14. Nondestructive Electric Test

14.1 As an alternative to the hydrostatic test at the option of the manufacturer or where specified in the purchase order as an alternative or addition to the hydrostatic test, the full body of each pipe shall be tested with a nondestructive electric test in accordance with Practice E 213, E 309, or E 570. In such cases, the marking of each length of pipe so furnished shall include the letters “NDE.” It is the intent of this nondestructive electric test to reject pipe with imperfections that produce test signals equal to or greater than that produced by the applicable calibration standard.

14.2 Where the nondestructive electric test is performed, the lengths shall be marked with the letters "NDE." The certification, where required, shall state "Nondestructive Electric Tested" and shall indicate which of the tests was applied. Also, the letters "NDE" shall be appended to the product specification number and material grade shown on the certification.

14.3 The following information is for the benefit of the user of this specification:

14.3.1 The reference standards defined in 14.4 through 14.6 are convenient standards for calibration of nondestructive testing equipment. The dimensions of such standards are not to be construed as the minimum sizes of imperfections detectable by such equipment.

14.3.2 The ultrasonic testing referred to in this specification is capable of detecting the presence and location of significant longitudinally or circumferentially oriented imperfections; however, different techniques need to be employed for the detection of such differently oriented imperfections. Ultrasonic testing is not necessarily capable of detecting short, deep imperfections.

14.3.3 The eddy current examination referenced in this specification has the capability of detecting significant imperfections, especially of the short abrupt type.

14.3.4 The flux leakage examination referred to in this specification is capable of detecting the presence and location of significant longitudinally or transversely oriented imperfections; however, different techniques need to be employed for the detection of such differently oriented imperfections.

14.3.5 The hydrostatic test referred to in Section 13 has the capability of finding defects of a size permitting the test fluid to leak through the tube wall and may be either visually seen or detected by a loss of pressure. Hydrostatic testing is not necessarily capable of detecting very tight, through-the-wall imperfections or imperfections that extend an appreciable distance into the wall without complete penetration.

14.3.6 A purchaser interested in ascertaining the nature (type, size, location, and orientation) of discontinuities that can be detected in the specific applications of these examinations is directed to discuss this with the manufacturer of the tubular product.

14.4 For ultrasonic testing, the calibration reference notches shall be, at the option of the producer, any one of the three common notch shapes shown in Practice E 213. The depth of notch shall not exceed 12½ % of the specified wall thickness of the pipe or 0.004 in. [0.1 mm], whichever is greater.

14.5 For eddy current testing, the calibration pipe shall contain, at the option of the producer, any one of the following discontinuities to establish a minimum sensitivity level for rejection:

14.5.1 *Drilled Hole*—The calibration pipe shall contain depending upon the pipe diameter three holes spaced 120° apart or four holes spaced 90° apart and sufficiently separated longitudinally to ensure separately distinguishable responses. The holes shall be drilled radially and completely through the pipe wall, care being taken to avoid distortion of the pipe while drilling. Depending upon the pipe diameter the calibration pipe shall contain the following hole:

NPS	DN	Diameter of Drilled Hole
≤ ½	≤ 15	0.039 in. [1 mm]
> ½ ≤ 1¼	> 15 ≤ 32	0.055 in. [1.4 mm]
> 1¼ ≤ 2	> 32 ≤ 50	0.071 in. [1.8 mm]
> 2 ≤ 5	> 50 ≤ 125	0.087 in. [2.2 mm]
> 5	> 125	0.106 in. [2.7 mm]

14.5.2 *Transverse Tangential Notch*—Using a round tool or file with a ¼-in. [6-mm] diameter, a notch shall be filed or milled tangential to the surface and transverse to the longitudinal axis of the pipe. The notch shall have a depth not exceeding 12½ % of the specified wall thickness of the pipe or 0.004 in. [0.1 mm], whichever is greater.

14.5.3 *Longitudinal Notch*—A notch 0.031 in. [0.8 mm] or less in width shall be machined in a radial plane parallel to the tube axis on the outside surface of the pipe, to have a depth not exceeding 12½ % of the specified wall thickness of the tube or 0.004 in. [0.1 mm], whichever is greater. The length of the notch shall be compatible with the testing method.

14.5.4 *Compatibility*—The discontinuity in the calibration pipe shall be compatible with the testing equipment and the method being used.

14.6 For flux leakage testing, the longitudinal calibration reference notches shall be straight-sided notches machined in a radial plane parallel to the pipe axis. For wall thicknesses under ½ in. [12.7 mm], outside and inside notches shall be used; for wall thicknesses equal to and above ½ in. [12.7 mm], only an outside notch shall be used. Notch depth shall not exceed 12½ % of the specified wall thickness, or 0.004 in. [0.1 mm], whichever is greater. Notch length shall not exceed 1 in. [25 mm], and the width shall not exceed the depth. Outside diameter and inside diameter notches shall be located sufficiently apart to allow separation and identification of the signals.

14.7 Pipe containing one or more imperfections that produce a signal equal to or greater than the signal produced by the calibration standard shall be rejected or the area producing the signal shall be reexamined.

14.7.1 Test signals produced by imperfections which cannot be identified, or produced by cracks or crack-like imperfections shall result in rejection of the pipe, unless it is repaired and retested. To be accepted, the pipe must pass the same specification test to which it was originally subjected, provided that the remaining wall thickness is not decreased below that permitted by this specification. The OD at the point of grinding may be reduced by the amount so reduced.

14.7.2 Test signals produced by visual imperfections such as those listed below may be evaluated in accordance with the provisions of Section 18:

- 14.7.2.1 Dinges,
- 14.7.2.2 Straightener marks,
- 14.7.2.3 Cutting chips,
- 14.7.2.4 Scratches,
- 14.7.2.5 Steel die stamps,
- 14.7.2.6 Stop marks, or

14.7.2.7 Pipe reducer ripple.

14.8 The test methods described in this section are not necessarily capable of inspecting the end portion of pipes, a condition referred to as "end effect." The length of such end effect shall be determined by the manufacturer and, when specified in the purchase order, reported to the purchaser.

15. Nipples

15.1 Nipples shall be cut from pipe of the same dimensions and quality described in this specification.

16. Dimensions, Mass, and Permissible Variations

16.1 *Mass*—The mass of any length of pipe shall not vary more than 10 % over and 3.5 % under that specified. Unless otherwise agreed upon between the manufacturer and the purchaser, pipe in NPS 4 [DN 100] and smaller may be weighed in convenient lots; pipe larger than NPS 4 [DN 100] shall be weighed separately.

16.2 *Diameter*—The tolerances for diameter shall be in accordance with the following:

16.2.1 Except for pipe ordered as special outside diameter tolerance pipe or as inside diameter tolerance pipe, variations in outside diameter shall not exceed those given in Table 3.

16.2.2 For pipe over 10 in. [250 mm] OD ordered as special outside diameter tolerance pipe, the outside diameter shall not vary more than 1 % over or 1 % under the specified outside diameter.

16.2.3 For pipe over 10 in. [250 mm] ID ordered as inside diameter tolerance pipe, the inside diameter shall not vary more than 1 % over or 1 % under the specified inside diameter.

16.3 *Thickness*—The minimum wall thickness at any point shall not be more than 12.5 % under the specified wall thickness.

17. Lengths

17.1 Pipe lengths shall be in accordance with the following regular practice:

17.1.1 The lengths required shall be specified in the order, and

17.1.2 No jointers are permitted unless otherwise specified.

17.1.3 If definite lengths are not required, pipe may be ordered in single random lengths of 16 to 22 ft [4.8 to 6.7 m] with 5 % 12 to 16 ft [3.7 to 4.8 m], or in double random lengths with a minimum average of 35 ft [10.7 m] and a minimum length of 22 ft [6.7 m] with 5 % 16 to 22 ft [4.8 to 6.7 m].

18. Workmanship, Finish and Appearance

18.1 The pipe manufacturer shall explore a sufficient number of visual surface imperfections to provide reasonable assurance that they have been properly evaluated with respect to depth. Exploration of all surface imperfections is not required but consideration should be given to the necessity of exploring all surface imperfections to assure compliance with 18.2.

18.2 Surface imperfections that penetrate more than 12½ % of the nominal wall thickness or encroach on the minimum wall thickness shall be considered defects. Pipe with such defects shall be given one of the following dispositions:

18.2.1 The defect shall be removed by grinding, provided that the remaining wall thickness is within the limits specified in 16.3.

18.2.2 Repaired in accordance with the repair welding provisions of 18.6.

18.2.3 The section of pipe containing the defect may be cut off within the limits of requirements on length.

18.2.4 Rejected.

18.3 To provide a workmanlike finish and basis for evaluating conformance with 18.2 the pipe manufacturer shall remove by grinding the following noninjurious imperfections:

18.3.1 Mechanical marks, abrasions (Note 5) and pits, any of which imperfections are deeper than ¼ in. [1.6 mm].

18.3.2 Visual imperfections commonly referred to as scabs, seams, laps, tears, or slivers found by exploration in accordance with 18.1 to be deeper than 5 % of the nominal wall thickness.

18.4 At the purchaser's discretion, pipe shall be subjected to rejection if surface imperfections acceptable under 18.2 are not scattered, but appear over a large area in excess of what is considered a workmanlike finish. Disposition of such pipe shall be a matter of agreement between the manufacturer and the purchaser.

18.5 When imperfections or defects are removed by grinding, a smooth curved surface shall be maintained, and the wall thickness shall not be decreased below that permitted by this specification. The outside diameter at the point of grinding is permitted to be reduced by the amount so removed.

18.5.1 Wall thickness measurements shall be made with a mechanical caliper or with a properly calibrated nondestructive testing device of appropriate accuracy. In case of dispute, the measurement determined by use of the mechanical caliper shall govern.

18.6 Weld repair shall be permitted only subject to the approval of the purchaser and in accordance with Specification A 530/A 530M.

18.7 The finished pipe shall be reasonably straight.

NOTE 5—Marks and abrasions are defined as cable marks, dinges, guide marks, roll marks, ball scratches, scores, die marks, etc.

TABLE 3 Variations in Outside Diameter

NPS [DN Designator]	Permissible Variations in Outside Diameter			
	Over		Under	
	In.	mm	In.	mm
½ to 1½ [6 to 40], incl	¼ (0.015)	0.4	¼ (0.015)	0.4
Over 1½ to 4 [40 to 100], incl	⅜ (0.031)	0.8	⅜ (0.031)	0.8
Over 4 to 8 [100 to 200], incl	⅜ (0.062)	1.6	⅜ (0.031)	0.8
Over 8 to 18 [200 to 450], incl	¾ (0.093)	2.4	⅜ (0.031)	0.8
Over 18 to 26 [450 to 650], incl	⅝ (0.125)	3.2	⅜ (0.031)	0.8
Over 26 to 34 [650 to 850], incl	¾ (0.156)	4.0	⅜ (0.031)	0.8
Over 34 to 48 [850 to 1200], incl	⅞ (0.187)	4.8	⅜ (0.031)	0.8



19. End Finish

19.1 The Pipe shall be furnished to the following practice, unless otherwise specified.

19.1.1 *NPS 1½ [DN 40] and Smaller*—All walls shall be either plain-end square cut, or plain-end beveled at the option of the manufacturer.

19.1.2 *NPS 2 [DN 50] and Larger*—Walls through extra strong weights, shall be plain-end-beveled.

19.1.3 *NPS 2 [DN 50] and Larger*—Walls over extra strong weights, shall be plain-end square cut.

NOTE 6—Plain-end beveled is defined as plain-end pipe having a bevel angle of 30°, +5° or -0°, as measured from a line drawn perpendicular to the axis of the pipe with a root face of $\frac{1}{16} \pm \frac{1}{32}$ in. [1.6 ± 0.8 mm]. Other bevel angles may be specified by agreement between the purchaser and the manufacturer.

20. Number of Tests

20.1 The tensile requirements specified in Section 7 shall be determined on one length of pipe from each lot (Note 3) of 400 lengths or fraction thereof of each size under NPS 6 [DN 150], and from each lot of 200 lengths or fraction thereof of each size NPS 6 [DN 150] and over.

20.2 For pipe NPS 2 [DN 50] and under, the bend test specified in 11.1 shall be made on one pipe from each lot of 400 lengths or fraction thereof of each size. The bend test, where used as permitted by 11.2 or required by 11.3, shall be made on one end of 5 % of the pipe from each lot. For small lots, at least one pipe shall be tested.

20.3 The flattening test specified in Section 12 shall be made on one length of pipe from each lot of 400 lengths or fraction thereof of each size over NPS 2 [DN 50], up to but not including NPS 6 [DN 150], and from each lot of 200 lengths or fraction thereof, of each size NPS 6 [DN 150] and over.

20.4 If any test specimen shows flaws or defective machining, it shall be permissible to discard it and substitute another test specimen.

21. Retests

21.1 If the percentage of elongation of any tension test specimen is less than that given in Table 1 and any part of the fracture is more than $\frac{3}{4}$ in. [19 mm] from the center of the gage length of a 2-in. [50-mm] specimen as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed. If a specimen breaks in an inside or outside surface flaw, a retest shall be allowed.

21.2 Should a crop end of a finished pipe fail in the flattening test, one retest is permitted to be made from the failed end. Pipe shall be normalized either before or after the first test, but pipe shall be subjected to only two normalizing treatments.

22. Test Specimens and Test Methods

22.1 On NPS 8 [DN 200] and larger, specimens cut either longitudinally or transversely shall be acceptable for the tension test. On sizes smaller than NPS 8 [DN 200], the longitudinal test only shall be used.

22.2 When round tension test specimens are used for pipe wall thicknesses over 1.0 in. [25.4 mm], the mid-length of the

longitudinal axis of such test specimens shall be from a location midway between the inside and outside surfaces of the pipe.

22.3 Test specimens for the bend test specified in Section 11 and for the flattening tests shall consist of sections cut from a pipe. Specimens for flattening tests shall be smooth on the ends and free from burrs, except when made on crop ends.

22.4 Test specimens for the bend test specified in 11.2 and 11.3 shall be cut from one end of the pipe and, unless otherwise specified, shall be taken in a transverse direction. One test specimen shall be taken as close to the outer surface as possible and another from as close to the inner surface as possible. The specimens shall be either $\frac{1}{2}$ by $\frac{1}{2}$ in. [12.5 by 12.5 mm] in section or 1 by $\frac{1}{2}$ in. [25 by 12.5 mm] in section with the corners rounded to a radius not over $\frac{1}{16}$ in. [1.6 mm] and need not exceed 6 in. [150 mm] in length. The side of the samples placed in tension during the bend shall be the side closest to the inner and outer surface of the pipe respectively.

22.5 All routine check tests shall be made at room temperature.

23. Certification

23.1 When test reports are requested, in addition to the requirements of Specification A 530/A 530M, the producer or supplier shall furnish to the purchaser a chemical analysis report for the elements specified in Table 1.

24. Product Marking

24.1 In addition to the marking prescribed in Specification A 530/A 530M, the marking shall include heat number, the information as per Table 4, an additional symbol "S" if one or more of the supplementary requirements apply; the length, OD 1 %, if ordered as special outside diameter tolerance pipe; ID 1 %, if ordered as special inside diameter tolerance pipe; the schedule number, weight class, or nominal wall thickness; and, for sizes larger than NPS 4 [DN 100], the weight. Length shall be marked in feet and tenths of a foot [metres to two decimal places], depending on the units to which the material was ordered, or other marking subject to agreement. For sizes NPS $1\frac{1}{2}$, $1\frac{1}{4}$, 1, and $\frac{3}{4}$ [DN 40, 32, 25, and 20], each length shall be marked as prescribed in Specification A 530/A 530M. These sizes shall be bundled in accordance with standard mill practice and the total bundle footage marked on the bundle tag; individual lengths of pipe need not be marked with footage. For sizes less than NPS $\frac{3}{4}$ [DN 20], all the required markings shall be on the bundle tag or on each length of pipe and shall include the total footage; individual lengths of pipe need not be marked with footage. If not marked on the bundle tag, all required marking shall be on each length.

24.2 When pipe sections are cut into shorter lengths by a subsequent processor for resale as material, the processor shall

TABLE 4 Marking

Hydro	NDE	Marking
Yes	No	Test Pressure
No	Yes	NDE
No	No	NH
Yes	Yes	Test Pressure/NDE

transfer complete identifying information, including the name or brand of the manufacturer to each unmarked cut length, or to metal tags securely attached to bundles of unmarked small diameter pipe. The same material designation shall be included with the information transferred, and the processor's name, trademark, or brand shall be added.

24.3 *Bar Coding*—In addition to the requirements in 24.1 and 24.2, bar coding is acceptable as a supplementary identification method. The purchaser may specify in the order a specific bar coding system to be used.

25. Government Procurement

25.1 When specified in the contract, material shall be preserved, packaged, and packed in accordance with the requirements of MIL-STD-163. The applicable levels shall be as specified in the contract. Marking for the shipment of such

material shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-129 or Fed. Std. No. 183 if continuous marking is required for military agencies.

25.2 *Inspection*—Unless otherwise specified in the contract, the producer is responsible for the performance of all inspection and test requirements specified herein. Except as otherwise specified in the contract, the producer shall use his own, or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless disapproved by the purchaser. The purchaser shall have the right to perform any of the inspections and tests set forth in this specification where such inspections are deemed necessary to ensure that the material conforms to the prescribed requirements.

26. Keywords

26.1 carbon steel pipe; seamless steel pipe; steel pipe

SUPPLEMENTARY REQUIREMENTS

One or more of the following supplementary requirements shall apply only when specified in the purchase order. The purchaser may specify a different frequency of test or analysis than is provided in the supplementary requirement. Subject to agreement between the purchaser and manufacturer, retest and retreatment provisions of these supplementary requirements may also be modified.

S1. Product Analysis

S1.1 Product analysis shall be made on each length of pipe. Individual lengths failing to conform to the chemical composition requirements shall be rejected.

S2. Transverse Tension Test

S2.1 A transverse tension test shall be made on a specimen from one end or both ends of each pipe NPS 8 [DN 200] and over. If this supplementary requirement is specified, the number of tests per pipe shall also be specified. If a specimen from any length fails to meet the required tensile properties (tensile, yield, and elongation), that length shall be rejected subject to retreatment in accordance with Specification A 530/A 530M and satisfactory retest.

S3. Flattening Test

S3.1 The flattening test of Specification A 530/A 530M shall be made on a specimen from one end or both ends of each pipe. Crop ends may be used. If this supplementary requirement is specified, the number of tests per pipe shall also be specified. If a specimen from any length fails because of lack of ductility prior to satisfactory completion of the first step of the flattening test requirement, that pipe shall be rejected subject to retreatment in accordance with Specification A 530/A 530M and satisfactory retest. If a specimen from any length of pipe fails because of a lack of soundness, that length shall be rejected, unless subsequent retesting indicates that the remaining length is sound.

S4. Metal Structure and Etching Test

S4.1 The steel shall be homogeneous as shown by etching tests conducted in accordance with the appropriate sections of Method E 381. Etching tests shall be made on a cross section

from one end or both ends of each pipe and shall show sound and reasonably uniform material free from injurious laminations, cracks, and similar objectionable defects. If this supplementary requirement is specified, the number of tests per pipe required shall also be specified. If a specimen from any length shows objectionable defects, the length shall be rejected, subject to removal of the defective end and subsequent retests indicating the remainder of the length to be sound and reasonably uniform material.

S5. Carbon Equivalent

S5.1 The steel shall conform to a carbon equivalent (CE) of 0.50 maximum as determined by the following formula:

$$CE = \%C + \frac{\%Mn}{6} + \frac{\%Cr + \%Mo + \%V}{5} + \frac{\%Ni + \%Cu}{15}$$

S5.2 A lower CE maximum may be agreed upon between the purchaser and the producer.

S5.3 The CE shall be reported on the test report.

S6. Heat Treated Test Specimens

S6.1 At the request of the purchaser, one tensile test shall be performed by the manufacturer on a test specimen from each heat of steel furnished which has been either stress relieved at 1250 °F or normalized at 1650 °F, as specified by the purchaser. Other stress relief or annealing temperatures, as appropriate to the analysis, may be specified by agreement between the purchaser and the manufacturer. The results of this test shall meet the requirements of Table 1.

S7. Internal Cleanliness—Government Orders

S7.1 The internal surface of hot finished ferritic steel pipe and tube shall be manufactured to a free of scale condition

equivalent to the visual standard listed in SSPC-SP6. Cleaning shall be performed in accordance with a written procedure that has been shown to be effective. This procedure shall be available for audit.

S8. Requirements for Carbon Steel Pipe for Hydrofluoric Acid Alkylation Service

S8.1 Pipe shall be provided in the normalized heat-treated condition.

S8.2 The carbon equivalent (CE), based upon heat analysis, shall not exceed 0.43 % if the specified wall thickness is equal to or less than 1 in. [25.4 mm] or 0.45 % if the specified wall thickness is greater than 1 in. [25.4 mm].

S8.3 The carbon equivalent (CE) shall be determined using the following formula:

$$CE = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15$$

S8.4 Based upon heat analysis in mass percent, the vanadium content shall not exceed 0.02 %, the niobium content shall not exceed 0.02 %, and the sum of the vanadium and niobium contents shall not exceed 0.03 %.

S8.5 Based upon heat analysis in mass percent, the sum of the nickel and copper contents shall not exceed 0.15 %.

S8.6 Based upon heat analysis in mass percent, the carbon content shall not be less than 0.18 %.

S8.7 Welding consumables of repair welds shall be of low hydrogen type. E60XX electrodes shall not be used and the resultant weld chemical composition shall meet the chemical composition requirements specified for the pipe.

S8.8 The designation “HF-N” shall be stamped or marked on each pipe to signify that the pipe complies with this supplementary requirement.

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this specification since the last issue, A 106 – 04a, that may impact the use of this specification. (Approved October 1, 2004)

(1) Revised 1.2 to delete the number of Supplementary Requirements.

(2) Revised 13.3 to permit the supply of hydrostatically tested or nondestructively tested pipe, and to prohibit the supply of pipe that has failed either test, both when NH pipe has been ordered.

Committee A01 has identified the location of selected changes to this specification since the last issue, A 106 – 04, that may impact the use of this specification. (Approved July 1, 2004)

(1) Editorially revised Supplementary Requirements S8.

Committee A01 has identified the location of selected changes to this specification since the last issue, A 106 – 02a, that may impact the use of this specification. (Approved March 1, 2004)

(1) Deleted Note 2 in 1.1.

(2) Deleted Tables 3 and 4 and renumbered subsequent tables.

(3) Deleted Appendixes X1 and X2.

(4) Included rationalized SI units throughout, creating a combined standard.

(5) Added Supplementary Requirements S8 for HF acid alkylation service.

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