

W11 Normal and higher strength hull structural steels

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(Rev.6 May
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1. Scope

1.1 These requirements apply to weldable normal and higher strength hot-rolled steel plates, wide flats, sections and bars intended for use in hull construction.

1.2 The requirements are primarily intended to apply to steel products with a thickness as follows:

For steel plates and wide flats;

- All Grades: Up to 100mm in thickness

For sections and bars;

- All Grades: Up to 50mm in thickness

For greater thickness certain variations in the requirements may be allowed or required in particular cases after consideration of the technical circumstances involved.

1.3 Provision is made for four grades of normal strength steel based on the impact test requirements. For higher strength steels provision is made for three strength levels (315, 355 and 390 N/mm²) each subdivided into four grades based on the impact test temperature.

1.4 Steels differing in chemical composition, deoxidation practice, conditions of supply and mechanical properties may be accepted, subject to the special approval of the Classification Society. Such steels are to be given a special designation.

2. Approval

2.1 All materials are to be manufactured at works which have been approved by the Classification Society for the type and grade of steel which is being supplied. The suitability of each grade of steel for forming and welding is to be demonstrated during the initial approval tests at the steelworks. Approval of the steel works is to follow a scheme given in the Appendix A. For the steels intended for high heat input welding over 50kJ/cm, the approval of the manufacturer is to follow a scheme given in the Appendix B.

2.2 It is the manufacturer's responsibility to assure that effective process and production controls in operation are adhered to within the manufacturing specifications. Where control imperfection inducing possible inferior quality of product occurs, the manufacturer is to identify the cause and establish a countermeasure to prevent its recurrence. Also, the complete investigation report is to be submitted to the Surveyor.

For further use, each affected piece is to be tested to the Surveyor's satisfaction.

The frequency of testing for subsequent products offered may be increased to gain confidence in the quality at the discretion of the Society.

2.3 When steel is not produced at the works at which it is rolled, a certificate is to be supplied to the Surveyor at the rolling mill stating the process by which it was manufactured, the name of the manufacturer who supplied it, the number of the cast from which it was made

W11
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and the ladle analysis. The Surveyor is to have access to the works at which the steel was produced.

Note:

1. The attention of the users must be drawn to the fact that when fatigue loading is present, the effective fatigue strength of a welded joint of higher strength steel may not be greater than that of a welded joint in normal strength steels.
2. Before subjecting steels produced by thermo-mechanical rolling to further heating for forming or stress relieving, or using high heat-input welding, special consideration must be given to the possibility of a consequent reduction in mechanical properties.

3. Method of Manufacture

3.1 Steel is to be manufactured by the basic oxygen, electric furnace or open hearth processes or by other processes specially approved by the Classification Society.

3.2 The deoxidation practice used for each grade is to comply with the appropriate requirements of Tables 1 and 2.

3.3 The rolling practice applied for each grade is to comply with the appropriate condition of supply of Tables 4 and 5.

The definitions of applicable rolling procedures and the schematic diagrams are given as follows:

- (i) As Rolled, AR
This procedure involves the rolling of steel at high temperature followed by air cooling. The rolling and finishing temperatures are typically in the austenite recrystallization region and above the normalising temperature. The strength and toughness properties of steel produced by this process are generally less than steel heat treated after rolling or than steel produced by advanced processes.
- (ii) Normalising, N
Normalising involves heating rolled steel above the critical temperature, A_{c3} , and in the lower end of the austenite recrystallization region followed by air cooling. The process improves the mechanical properties of as rolled steel by refining the grain size.
- (iii) Controlled Rolling, CR (Normalizing Rolling, NR):
A rolling procedure in which the final deformation is carried out in the normalising temperature range, resulting in a material condition generally equivalent to that obtained by normalising.
- (iv) Quenching and Tempering, QT
Quenching involves a heat treatment process in which steel is heated to an appropriate temperature above the A_{c3} and then cooled with an appropriate coolant for the purpose of hardening the microstructure. Tempering subsequent to quenching is a process in which the steel is reheated to an appropriate temperature not higher than the A_{c1} to restore toughness properties by improving the microstructure.
- (v) Thermo-Mechanical Rolling, TM (Thermo-Mechanical Controlled Processing, TMCP):
This is a procedure which involves the strict control of both the steel temperature and the rolling reduction. Generally a high proportion of the rolling reduction is carried out close to the A_{r3} temperature and may involve the rolling in the dual phase temperature region.

W11
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Unlike controlled rolled (normalised rolling) the properties conferred by TM (TMCP) cannot be reproduced by subsequent normalising or other heat treatment.

The use of accelerated cooling on completion of TM-rolling may also be accepted subject to the special approval of the Society. The same applies for the use of tempering after completion of the TM-rolling.

(vi) Accelerated Cooling, AcC

Accelerated cooling is a process, which aims to improve mechanical properties by controlled cooling with rates higher than air cooling immediately after the final TM-rolling operation. Direct quenching is excluded from accelerated cooling.

The material properties conferred by TM and AcC cannot be reproduced by subsequent normalising or other heat treatment.

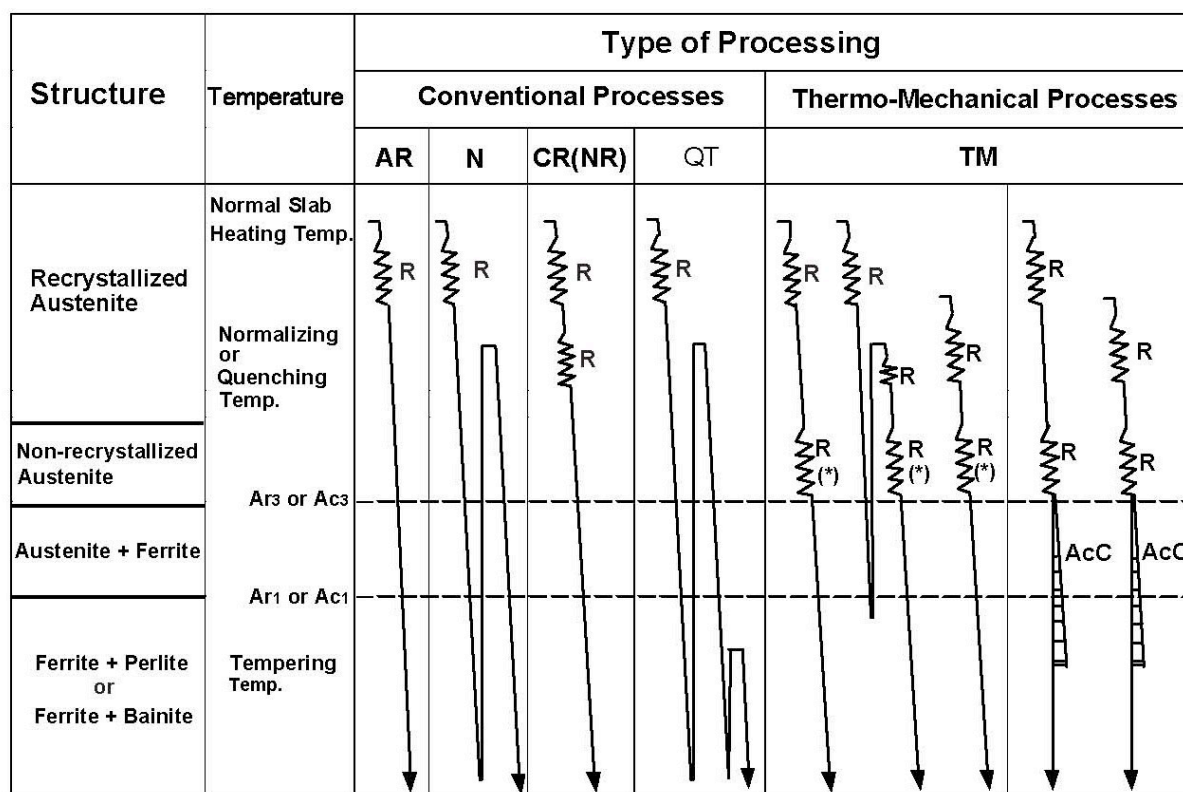
Where CR and TM with/without AcC are applied, the programmed rolling schedules are to be verified by the Classification Society at the time of the steel works approval, and are to be made available when required by the attending Surveyor. On the manufacturer's responsibility, the programmed rolling schedules are to be adhered to during the rolling operation. Refer to the above 2.2. To this effect, the actual rolling records are to be reviewed by the manufacturer and occasionally by the Surveyor.

When deviation from the programmed rolling schedules or normalizing or quenching and tempering procedures occurs, the manufacturer shall take further measures required in the above 2.2 to the Surveyor's satisfaction.

W11

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Schematic Diagrams of Thermo-Mechanical and Conventional Processes



Notes:

- AR: As Rolled
- N: Normalizing
- CR(NR): Controlled Rolling (Normalizing Rolling)
- QT: Quenching and Tempering
- TM: Thermo-Mechanical Rolling (Thermo-Mechanical Controlled Process)
- R: Reduction
- (*): Sometimes rolling in the dual-phase temperature region of austenite and ferrite
- AcC: Accelerated Cooling

4. Chemical Composition

4.1 The chemical composition of samples taken from each ladle of each cast is to be determined by the manufacturer in an adequately equipped and competently staffed laboratory and is to comply with the appropriate requirements of Tables 1 and 2. For steel plates and wide flats over 50 mm thick, slight deviations in the chemical composition may be allowed as approved by the Classification Society.

4.2 The manufacturer's declared analysis will be accepted subject to occasional checks if required by the Surveyor.

Table 1 Chemical composition and deoxidation practice for normal strength steels

Grade	A	B	D	E
Deoxidation Practice	For t ≤ 50 mm Any method except rimmed steel ⁽¹⁾ For t > 50 mm Killed	For t ≤ 50 mm Any method except rimmed Killed For t > 50 mm Killed	For t ≤ 25 mm Killed For t > 25 mm Killed and fine grain treated	Killed and fine grain treated
Chemical Composition % ^{(4) (7) (8)} (ladle samples)	Carbon plus 1/6 of the manganese content is not to exceed 0.40%			
C max.	0.21 ⁽²⁾	0.21	0.21	0.18
Mn min.	2.5 x C	0.80 ⁽³⁾	0.60	0.70
Si max.	0.50	0.35	0.35	0.35
P max.	0.035	0.035	0.035	0.035
S max.	0.035	0.035	0.035	0.035
Al (acid soluble min)	-	-	0.015 ^{(5) (6)}	0.015 ⁽⁶⁾

t = thickness

Notes:

- Grade A sections up to a thickness of 12.5 mm may be accepted in rimmed steel subject to the special approval of the Classification Society.
- Max. 0.23% for sections.
- When Grade B steel is impact tested the minimum manganese content may be reduced to 0.60%.
- When any grade of steel is supplied in the thermo-mechanically rolled condition variations in the specified chemical composition may be allowed or required by the Classification Society.
- For Grade D steel over 25 mm thick.
- For Grade D steel over 25 mm thick and Grade E steel the total aluminium content may be determined instead of acid soluble content. In such cases the total aluminium content is to be not less than 0.020%. A maximum aluminium content may also be specified by the Classification Society. Other suitable grain refining elements may be used subject to the special approval of the Classification Society.
- The Classification Society may limit the amount of residual elements which may have an adverse effect on the working and use of the steel, e.g. copper and tin.
- Where additions of any other element have been made as part of the steelmaking practice, the content is to be indicated.

Table 2 Chemical composition and deoxidation practice for higher strength steels

Grade ⁽¹⁾	A32	D32	E32	F32
	A36	D36	E36	F36
	A40	D40	E40	F40
Deoxidation Practice	killed and fine grain treated			
Chemical Composition % ^{(5) (7)} (ladle samples)				
C max.	0.18			0.16
Mn	0.90 – 1.60 ⁽²⁾			0.90 – 1.60
Si max.	0.50			0.50
P max.	0.035			0.025
S max.	0.035			0.025
Al (acid soluble min)	0.015 ^{(3) (4)}			0.015 ^{(3) (4)}
Nb	0.02 – 0.05 ⁽⁴⁾	total:	0.02 – 0.05 ⁽⁴⁾	total:
V	0.05 – 0.10 ⁽⁴⁾	0.12	0.05 – 0.10 ⁽⁴⁾	0.12
Ti max.	0.02) max.	0.02) max.
Cu max.	0.35		0.35	
Cr max.	0.20		0.20	
Ni max.	0.40		0.80	
Mo max.	0.08		0.08	
N max.	-		0.009 (0.012 if Al is present)	
Carbon Equivalent ⁽⁶⁾				

Notes:

- The letter "H" may be added either in front or behind the grade mark e.g. HA 32 or AH 32.
- Up to a thickness of 12.5 mm the minimum manganese content may be reduced to 0.70%.
- The total aluminium content may be determined instead of the acid soluble content. In such cases the total aluminium content is to be not less than 0.020%.
- The steel is to contain aluminium, niobium, vanadium or other suitable grain refining elements, either singly or in any combination. When used singly the steel is to contain the specified minimum content of the grain refining element. When used in combination, the specified minimum content of a fine graining element is not applicable.
- When any grade of higher strength steel is supplied in the thermo-mechanically rolled condition variations in the specified chemical composition may be allowed or required by the Classification Society.
- When required, the carbon equivalent value is to be calculated from the ladle analysis using the following formula.

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \quad (\%)$$

This formula is applicable only to steels which are basically of the carbon-manganese type and gives a general indication of the weldability of the steel.

- Where additions of any other element have been made as part of the steelmaking practice, the content is to be indicated.

4.3 For TM (TMCP) steels the following special requirements apply:

- The carbon equivalent value is to be calculated from the ladle analysis using the following formula and to comply with the requirements of Table 3;

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \quad (\%)$$

- The following formula (cold cracking susceptibility) may be used for evaluating weldability instead of the carbon equivalent at the discretion of the Classification Society;

W11

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$$P_{cm} = C + \frac{Si}{30} + \frac{Mn}{20} + \frac{Cu}{20} + \frac{Ni}{60} + \frac{Cr}{20} + \frac{Mo}{15} + \frac{V}{10} + 5B \%$$

In such cases the cold cracking susceptibility value required may be specified by the Classification Society.

Table 3 Carbon equivalent for higher strength steels up to 100 mm in thickness produced by TM

Grade	Carbon Equivalent, max. (%) ⁽¹⁾	
	t ≤ 50	50 < t ≤ 100
A32, D32, E32, F32	0.36	0.38
A36, D36, E36, F36	0.38	0.40
A40, D40, E40, F40	0.40	0.42

t: thickness (mm)

Notes:

- (1) It is a matter for the manufacturer and shipbuilder to mutually agree in individual cases as to whether they wish to specify a more stringent carbon equivalent.

5. Condition of Supply

5.1 All materials are to be supplied in a condition complying with the appropriate requirements of Tables 4 and 5.

Table 4 Condition of supply for normal strength steels ⁽¹⁾

Grades	Thickness	Condition of Supply
A	≤ 50 mm	Any
	> 50 mm ≤ 100 mm	Normalized, controlled rolled or thermo-mechanically rolled ⁽²⁾
B	≤ 50 mm	Any
	> 50 mm ≤ 100 mm	Normalized, controlled rolled or thermo-mechanically rolled ⁽²⁾
D	≤ 35 mm	Any
	> 35 mm ≤ 100 mm	Normalized, controlled rolled or thermo-mechanically rolled ⁽³⁾
E	≤ 100 mm	Normalized or thermo-mechanically rolled ⁽³⁾

Notes:

- (1) These conditions of supply and the impact test requirements are summarised in Table 8.
 (2) Subject to the special approval of the Classification Society, Grades A and B steel plates may be supplied in the as rolled condition - see 11.13.2 (ii).
 (3) Subject to the special approval of the Classification Society, sections in Grade D steel may be supplied in the as rolled condition provided satisfactory results are consistently obtained from Charpy V-notch impact tests. Similarly sections in Grade E steel may be supplied in the as rolled or controlled rolled condition. The frequency of impact tests is to be in accordance with W11.13.2 (ii) and W11.13.3 (iii) respectively.

Table 5 Condition of supply for higher strength steels ⁽¹⁾

Grades	Grain Refining Elements Used	Thickness	Condition of supply
A32 A36	Nb and/or V	≤ 12.5 mm	Any
		> 12.5 mm ≤ 100 mm	Normalized, controlled rolled or thermo-mechanically rolled ⁽³⁾
	Al alone or with Ti	≤ 20 mm	Any
		> 20 mm ≤ 35 mm	Any, as rolled subject to special approval of the Classification Society ⁽²⁾
	> 35 mm ≤ 100 mm	Normalized, controlled rolled or thermo-mechanically rolled ⁽³⁾	
A40	Any	≤ 12.5 mm	Any
		> 12.5 mm ≤ 50 mm	Normalized, controlled rolled or thermo-mechanically rolled
		> 50 mm ≤ 100 mm	Normalized, thermo-mechanically rolled or quenched and tempered
D32 D36	Nb and/or V	≤ 12.5 mm	Any
		> 12.5 mm ≤ 100 mm	Normalized, controlled rolled or thermo-mechanically rolled ⁽³⁾
	Al alone or with Ti	≤ 20 mm	Any
		> 20 mm ≤ 25 mm	Any, as rolled subject to special approval of the Classification Society ⁽²⁾
	> 25 mm ≤ 100 mm	Normalized, controlled rolled or thermo-mechanically rolled ⁽³⁾	
D40	Any	≤ 50 mm	Normalized, controlled rolled or thermo-mechanically rolled
		> 50 mm ≤ 100 mm	Normalized, thermo-mechanically rolled or quenched and tempered
E32 E36	Any	≤ 50 mm	Normalized or thermo-mechanically rolled ⁽³⁾
		> 50 mm ≤ 100 mm	Normalized, thermo-mechanically rolled
E40	Any	≤ 50 mm	Normalized, thermo-mechanically rolled or quenched and tempered
		> 50 mm ≤ 100 mm	Normalized, thermo-mechanically rolled or quenched and tempered
F32 F36 F40	Any	≤ 50 mm	Normalized, thermo-mechanically rolled or quenched and tempered ⁽⁴⁾
		> 50 mm ≤ 100 mm	Normalized, thermo-mechanically rolled or quenched and tempered

Notes:

- (1) These conditions of supply and the requirements for impact tests are summarised in Table 9.
- (2) The frequency of impact tests is to be in accordance with W11.13.2 (ii).
- (3) Subject to the special approval of the Classification Society, sections in Grades A32, A36, D32 and D36 steels may be supplied in the as rolled condition provided satisfactory results are consistently obtained from Charpy V-notch impact tests. Similarly sections in Grades E32 and E36 steels may be supplied in the as rolled or controlled rolled condition. The frequency of impact tests is to be in accordance with W11.13.2 (ii) and W11.13.2 (iii) respectively.
- (4) Subject to the special approval of the Classification Society, sections in Grades F32 and F36 steels may be supplied in the controlled rolled condition. The frequency of impact tests is to be in accordance with W11.13.3 (iii).

W11

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6. Mechanical Properties

6.1 For tensile test either the upper yield stress (ReH) or where ReH cannot be determined, the 0.2 percent proof stress (Rp 0.2) is to be determined and the material is considered to comply with the requirements if either value meets or exceeds the specified minimum value for yield strength (Re).

6.2 The results obtained from tensile tests are to comply with the appropriate requirements of Tables 6 and 7.

Table 6 Mechanical properties for normal strength steels

Grade	Yield Strength ReH (N/mm ²) min	Tensile Strength Rm (N/mm ²)	Elongation (5.65 √S ₀) A ₅ (%)	Impact Test						
				Test Temp. °C	Average Impact Energy (J) min					
					t ≤ 50		50 < t ≤ 70		70 < t ≤ 100	
					Long ⁽³⁾	Trans ⁽³⁾	Long ⁽³⁾	Trans ⁽³⁾	Long ⁽³⁾	Trans ⁽³⁾
A				+20	-	-	34 ⁽⁵⁾	24 ⁽⁵⁾	41 ⁽⁵⁾	27 ⁽⁵⁾
B	235	400/520 ⁽¹⁾	22 ⁽²⁾	0	27 ⁽⁴⁾	20 ⁽⁴⁾	34	24	41	27
D				-20	27	20	34	24	41	27
E				-40	24	20	34	24	41	27

t: thickness (mm)

Notes:

- (1) For all thicknesses of Grade A sections the upper limit for the specified tensile strength range may be exceeded at the discretion of the Classification Society.
- (2) For full thickness flat tensile test specimens with a width of 25 mm and a gauge length of 200mm the elongation is to comply with the following minimum values:

Thickness mm	> 5	> 10	> 15	> 20	> 25	> 30	> 40
	≤ 5	≤ 10	≤ 15	≤ 20	≤ 25	≤ 30	≤ 50
Elongation %	14	16	17	18	19	20	22

- (3) See paragraph W11.6.3.
- (4) Charpy V-notch impact tests are generally not required for Grade B steel with thickness of 25 mm or less.
- (5) Impact tests for Grade A over 50 mm thick are not required when the material is produced using fine grain practice and furnished normalised. TM rolling may be accepted without impact testing at the discretion of the Society.

Table 7 Mechanical properties for higher strength steels

Grade	Yield Strength ReH (N/mm ²) min	Tensile Strength Rm (N/mm ²)	Elongation (5.65 √S ₀) A ₅ (%)	Impact Test						
				Test Temp. °C	Average Impact Energy (J) min					
					t ≤ 50		50 < t ≤ 70		70 < t ≤ 100	
					Long ⁽²⁾	Trans ⁽²⁾	Long ⁽²⁾	Trans ⁽²⁾	Long ⁽²⁾	Trans ⁽²⁾
A32	315	440/570	22 ⁽¹⁾	0	31 ⁽³⁾	22 ⁽³⁾	38	26	46	31
D32				-20	31	22	38	26	46	31
E32				-40	31	22	38	26	46	31
F32				-60	31	22	38	26	46	31
A36	355	490/630	21 ⁽¹⁾	0	34 ⁽³⁾	24 ⁽³⁾	41	27	50	34
D36				-20	34	24	41	27	50	34
E36				-40	34	24	41	27	50	34
F36				-60	34	24	41	27	50	34
A40	390	510/660	20 ⁽¹⁾	0	39	26	46	31	55	37
D40				-20	39	26	46	31	55	37
E40				-40	39	26	46	31	55	37
F40				-60	39	26	46	31	55	37

t: thickness (mm)

Notes:

- (1) For full thickness flat tensile test specimens with a width of 25mm and a gauge length of 200 mm the elongation is to comply with the following minimum values:

Thickness (mm)	Grade	> 5	> 10	> 15	> 20	> 25	> 30	> 40	
		≤ 5	≤ 10	≤ 15	≤ 20	≤ 25	≤ 30	≤ 40	≤ 50
Elongation %	A32, D32, E32 & F32	14	16	17	18	19	20	21	22
	A36, D36, E36 & F36	13	15	16	17	18	19	20	21
	A40, D40, E40 & F40	12	14	15	16	17	18	19	20

- (2) See paragraph W11.6.3.
 (3) For Grades A32 and A36 steels a relaxation in the number of impact tests for acceptance purposes may be permitted by special agreement with the Classification Society provided that satisfactory results are obtained from occasional check tests.

6.3 Minimum average energy values are specified for Charpy V-notch impact test specimens taken in either the longitudinal or transverse directions (see W11.12.2). Generally only longitudinal test specimens need to be prepared and tested except for special applications where transverse test specimens may be required by the purchaser or the Classification Society. Transverse test results are to be guaranteed by the supplier.

The tabulated values are for standard specimens 10 mm x 10 mm. For plate thicknesses less than 10 mm, impact test may be waived at the discretion of the Classification Society or sub-size specimens, as specified in UR W2, may be used.

6.4 The average value obtained from one set of three impact tests is to comply with the requirements given in Tables 6 and 7. One individual value only may be below the specified average value provided it is not less than 70% of that value.

W11
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6.5 Generally, impact tests are not required when the nominal plate thickness is less than 6 mm.

7. Freedom from Defects

7.1 The steel is to be reasonably free from segregations and non-metallic inclusions. The finished material is to have a workmanlike finish and is to be free from internal and surface defects prejudicial to the use of the material for the intended application.

7.2 The acceptance criteria for surface finish and procedures for the repair of defects, as detailed in Recommendation, No 12, "Guidance for the Surface Finish of Hot Rolled Steel Plates and Wide Flats" are to be observed.

8. Tolerances

8.1 Unless otherwise agreed or specially required the thickness tolerances in Unified Requirement W13 "Allowable under thickness tolerances of steel plates and wide flats" are applicable.

9. Identification of Materials

9.1 The steelmaker is to adopt a system for the identification of ingots, slabs and finished pieces which will enable the material to be traced to its original cast.

9.2 The Surveyor is to be given full facilities for so tracing the material when required.

10. Testing and Inspection**10.1 Facilities for Inspection**

The manufacturer is to afford the Surveyor all necessary facilities and access to all relevant parts of the works to enable him to verify that the approved process is adhered to, for the selection of test materials, and the witnessing of tests, as required by the Rules, and for verifying the accuracy of the testing equipment.

10.2 Testing Procedures

The prescribed tests and inspections are to be carried out at the place of manufacture before dispatch. The test specimens and procedures are to be in accordance with Unified Requirement W2 "Test Specimens and Mechanical Testing Procedures for Materials". All the test specimens are to be selected and stamped by the Surveyor and tested in his presence, unless otherwise agreed.

10.3 Through Thickness Tensile Tests

If plates and wide flats with thickness of 15 mm and over are ordered with through thickness properties, the through thickness tensile test in accordance with Unified Requirement W14 "Steel Plates and Wide Flats with Improved Through Thickness Properties" is to be carried out.

W11
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10.4 Ultrasonic Inspection

If plates and wide flats are ordered with ultrasonic inspection, this is to be made in accordance with an accepted standard at the discretion of the Classification Society.

10.5 Surface Inspection and Dimensions

Surface inspection and verification of dimensions are the responsibility of the steel maker. The acceptance by the Classification Society's Surveyor shall not absolve the steel maker from this responsibility.

11. Test Material

11.1 Definitions

- (a) Piece: the term "piece" is understood to mean the rolled product from a single slab, billet or ingot if this is rolled directly into plates, sections or bars.
- (b) Batch: a number of similar pieces presented as a group for acceptance tests.

11.2 Test Samples

- (a) All material in a batch presented for acceptance tests is to be of the same product form e.g. plates, flats, sections, etc. from the same cast and in the same condition of supply.
- (b) The test samples are to be fully representative of the material and, where appropriate, are not to be cut from the material until heat treatment has been completed.
- (c) The test specimens are not to be separately heat treated in any way.
- (d) Unless otherwise agreed the test samples are to be taken from the following positions:
 - (i) *Plates and flats with a width ≥ 600 mm.* The test samples are to be taken from one end at a position approximately midway between the axis in the direction of the rolling and the edge of the rolled product (see Fig. 1). Unless otherwise agreed the tensile test specimens are to be prepared with their longitudinal axes transverse to the final direction of rolling.
 - (ii) *Flats with a width < 600 mm, bulb flats and other sections.* The test samples are to be taken from one end at a position approximately one third from the outer edge (see Figs. 2, 3 and 4) or in the case of small sections, as near as possible to this position. In the case of channels, beams or bulb angles, the test samples may alternatively be taken from a position approximately one quarter of the width from the web centre line or axis (see Fig. 3). The tensile test specimens may be prepared with their longitudinal axes either parallel or transverse to the final direction of rolling.
 - (iii) *Bars and other similar products.* The test samples are to be taken so that the longitudinal axes of the test specimens are parallel to the direction of rolling and are as near as possible to the following
 - for non-cylindrical sections, at one third of the half diagonal from the outside,
 - for cylindrical sections, at one third of the radius from the outside (see Fig. 6).

W11

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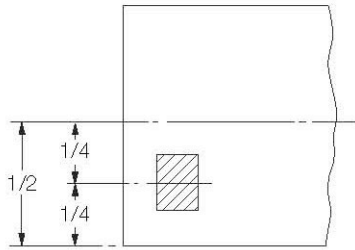


Fig. 1 Plates and flats

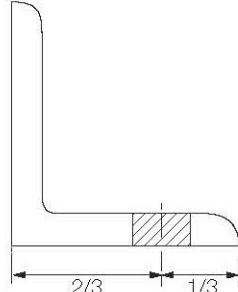


Fig. 2 Angles

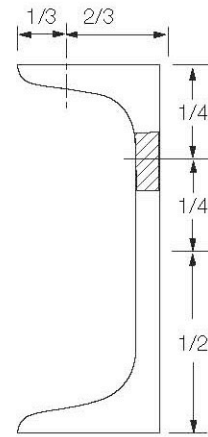


Fig. 3 Channel

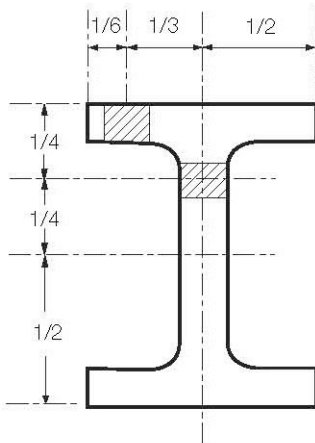


Fig. 4 H-sections

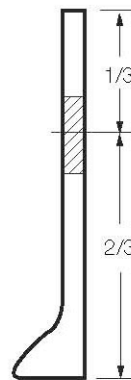


Fig. 5 Bulb flats

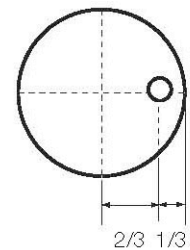


Fig. 6 Bars;

12. Mechanical Test specimens

12.1 Tensile Test Specimens. The dimensions of the tensile test specimens are to be in accordance with Unified Requirement, W2. Generally for plates, wide flats and sections flat test specimens of full product thickness are to be used. Round test specimens may be used when the product thickness exceeds 40 mm or for bars and other similar products. Alternatively for small sizes of bars, etc. test specimens may consist of a suitable length of the full cross section of the product.

12.2 Impact Test Specimens. The impact test specimens are to be of the Charpy V-notch type cut with their edge within 2 mm from the "as rolled" surface with their longitudinal axes either parallel (indicated "Long" in Table 6 & 7) or transverse (indicated "Trans" in Tables 6 & 7) to the final direction of rolling of the material. The notch is to be cut in a face of the test specimen which was originally perpendicular to the rolled surface. The position of the notch is not to be nearer than 25 mm to a flame cut or sheared edge (see also W11.6.3). Where the product thickness exceeds 40 mm, the impact test specimens are to be taken with their longitudinal axis at a quarter thickness position.

W11
(cont)**13. Number of Test Specimens**

13.1 Number of Tensile Tests. For each batch presented, except where specially agreed by the Classification Society, one tensile test is to be made from one piece unless the weight of finished material is greater than 50 tonnes or fraction thereof. Additionally tests are to be made for every variation of 10 mm in the thickness or diameter of products from the same cast.

13.2 Number of Impact Tests (except for Grades E, E32, E36, E40, F32, F36 and F40), see Tables 8 & 9.

- (i) Except where otherwise specified or specially agreed by the Classification Society, for each batch presented, at least one set of three Charpy V-notch test specimens is to be made from one piece unless the weight of finished material is greater than 50 tonnes, in which case one extra set of three test specimens is to be made from a different piece from each 50 tonnes or fraction thereof. When steel plates except for Grade A steel over 50 mm in thickness is supplied in the controlled rolled condition, the frequency of impact test is to be made from a different piece from each 25 tonnes or fraction thereof.
- (ii) For steel plates of Grades A40 and D40 with thickness over 50 mm in normalized or TM condition, one set of impact test specimens is to be taken from each batch of 50 tonnes or fraction thereof. For those in QT condition, one set of impact test specimens is to be taken from each length as heat treated.
- (iii) When, subject to the special approval of the Classification Society, material is supplied in the as rolled condition, the frequency of impact tests is to be increased to one set from each batch of 25 tonnes or fraction thereof. Similarly Grade A steel over 50 mm in thickness may be supplied in the as rolled condition. In such case one set of three Charpy V-notch test specimens is to be taken from each batch of 50 tonnes or fraction thereof.
- (iv) The piece selected for the preparation of the test specimens is to be the thickest in each batch.

13.3 Number of Impact Tests (Grades E, E32, E36, E40, F32, F36 and F40).

- (i) For steel plates supplied in the normalised or TM condition one set of impact test specimens is to be taken from each piece. For quenched and tempered steel plates one set of impact test specimens is to be taken from each length as heat treated.
- (ii) For sections one set of impact tests is to be taken from each batch of 25 tonnes or fraction thereof.
- (iii) When, subject to the special approval of the Classification Society, sections other than Grades E40 and F40 are supplied in the as rolled or controlled rolled condition, one set of impact tests is to be taken from each batch of 15 tonnes or fraction thereof.
- (iv) For (ii) and (iii) above the piece selected for the preparation of the test specimens is to be the thickest in each batch.

W11
(cont)**14. Retest Procedures**

14.1 When the tensile test from the first piece selected in accordance with W11.13.1 fails to meet the requirements re-test requirements for tensile tests are to be in accordance with UR W2.

14.2 If one or both of the additional tests referred to above are unsatisfactory, the piece is to be rejected, but the remaining material from the same batch may be accepted provided that two of the remaining pieces in the batch selected in the same way, are tested with satisfactory results. If unsatisfactory results are obtained from either of these two pieces then the batch of material is to be rejected.

14.3 Re-test requirements for Charpy impact tests are to be in accordance with UR W2.

14.4 When the initial piece, representing a batch, gives unsatisfactory results from the additional Charpy V-notch impact tests referred to above, this piece is to be rejected but the remaining material in the batch may be accepted provided that two of the remaining pieces in the batch are tested with satisfactory results. If unsatisfactory results are obtained from either of these two pieces then the batch of material is to be rejected. The pieces selected for these additional tests are to be the thickest remaining in the batch.

14.5 If any test specimen fails because of faulty preparation, visible defects or (in the case of tensile test) because of fracturing outside the range permitted for the appropriate gauge length, the defective test piece may, at the Surveyors discretion, be disregarded and replayed by an additional test piece of the same type.

14.6 At the option of the steelmaker, when a batch of material is rejected, the remaining pieces in the batch may be resubmitted individually for test and those pieces which give satisfactory results may be accepted.

14.7 At the option of the steelmaker, rejected material may be resubmitted after heat treatment or reheat treatment, or may be resubmitted as another grade of steel and may then be accepted provided the required tests are satisfactory.

14.8 In the event of any material proving unsatisfactory during subsequent working or fabrication, such material may be rejected, notwithstanding any previous satisfactory testing and/or certification.

15. Branding

15.1 Every finished piece is to be clearly marked by the maker in at least one place with the Classification Society's brand and the following particulars:

- (i) Unified identification mark for the grade steel (e.g. A, A36).
- (ii) Steels which have been specially approved by the Classification Society and which differ from these requirements (see W11.1.4) are to have the letter "S" after the above identification mark (e.g. A36S, ES).
- (iii) When required by the Classification Society, material supplied in the thermo-mechanically controlled process condition is to have the letters TM added after the identification mark (e.g. E36 TM).
- (iv) Name or initials to identify the steelworks.
- (v) Cast or other number to identify the piece.
- (vi) If required by the purchaser, his order number or other identification mark.

W11
(cont)

15.2 The above particulars, but excluding the manufacturer's name or trade mark where this is embossed on finished products are to be encircled with paint or otherwise marked so as to be easily recognisable.

15.3 Where a number of light materials are securely fastened together in bundles the manufacturer may, subject to the agreement of the Classification Society, brand only the top piece of each bundle, or alternatively, a firmly fastened durable label containing the brand may be attached to each bundle.

15.4 In the event of any material bearing the Classification Society's brand failing to comply with the test requirements, the brand is to be unmistakably defaced by the manufacturer.

16. Documentation

16.1 The Surveyor is to be supplied with the number of copies as required by the Classification Society, of the test certificates or shipping statements for all accepted materials. The Classification Society may require separate documents of each grade of steel. These documents are to contain, in addition to the description, dimensions, etc., of the material, at least the following particulars:

- (i) Purchaser's order number and if known the hull number for which the material is intended.
- (ii) Identification of the cast and piece including, where appropriate, the test specimen number.
- (iii) Identification of the steelworks.
- (iv) Identification of the grade of steel.
- (v) Ladle analysis (for elements specified in Tables 1 & 2).
- (vi) Condition of supply when other than as rolled i.e. normalised, controlled rolled or thermomechanically rolled.
- (vii) State if rimming steel has been supplied for grade A sections, up to 12.5 mm thick.
- (viii) Test Results

16.2 Before the test certificates or shipping statements are signed by the Surveyor, the manufacturer is required to furnish him with a written declaration stating that the material has been made by an approved process and that it has been subjected to and has withstood satisfactory the required tests in the presence of the Surveyor or his authorized deputy. The name of the Classification Society is to appear on the test certificate. The following form of declaration will be accepted if stamped or printed on each test certificate or shipping statement with the name of the steelworks and initialled for the makers by an authorized official:

"We hereby certify that the material has been made by an approved process and has been satisfactorily tested in accordance with the Rules of the Classification Society."

W11

(cont)

Table 8 Required condition of supply and number of impact tests for normal strength steels

Grade	Deoxidation Practice	Products	Condition of Supply (Batch for Impact Tests) (1)(2)								
			Thickness (mm)								
			10	12.5	20	25	30	35	40	50	100
A	Rimmed	Sections	A(-)	Not applicable							
	For t ≤ 50mm Any method except rimmed For t > 50mm Killed	Plates	A(-)						N(-) TM(-) (3) CR (50), AR* (50)		
		Sections	A(-)						Not applicable		
B	For t ≤ 50mm Any method except rimmed For t > 50mm Killed	Plates	A(-)				A(50)	N(50) TM(50) CR (25), AR* (25)			
		Sections	A(-)				A(50)	Not applicable			
D	Killed	Plates Sections	A(50)	Not applicable							
	Plates Killed and fine grain treated	Plates	A(50)				N(50) CR(50) TM(50)	N(50) TM(50) CR(25)			
		Sections	A(50)				N(50) CR(50) TM(50) AR*(25)	Not applicable			
E	Killed and fine grain treated	Plates	N(Each piece) TM(Each piece)								
		Sections	N(25) TM(25) AR* (15), CR*(15)					Not applicable			

Remarks:

- Condition of Supply
 - A – Any
 - N – Normalised Condition
 - CR – Controlled Rolled Condition
 - TM – Thermo-Mechanical rolling
 - AR* – As Rolled Condition subject to special approval of the Classification Society
 - CR* – Controlled Rolled Condition subject to special approval of the Classification Society
- Number of Impact Tests
One set of impact tests is to be taken from each batch of the "specified weight" in () or fraction thereof.
- See Note (5) of Table 6.

W11
(cont)**Table 9 Required condition of supply and number of impact tests for higher strength steels**

Grade	Deoxidation Practice	Grain Refining Elements	Products	Condition of supply (Batch for Impact Tests ⁽¹⁾⁽²⁾)								
				Thickness (mm)								
				10	12.5	20	25	30	35	40	50	100
A32 A36	Killed and fine grain treated	Nb and/or V	Plates	A(50)	N(50) CR(50),TM(50)					N(50), CR(25), TM(50)		
			Sections	A(50)	N(50) CR(50), TM(50) AR* (25)					Not applicable		
		Al alone or with Ti	Plates	A(50)	AR*(25)		Not applicable					
			Sections	A(50)	N(50) CR(50) TM(50) AR*(25)					Not applicable		
A40	Killed and fine grain treated	Any	Plates	A(50)	N(50) CR(50) TM(50)					N(50) TM(50) QT(Each length as heat treated)		
			Sections	A(50)	N(50) CR(50) TM(50)					Not applicable		
D32 D36	Killed and fine grain treated	Nb and/or V	Plates	A(50)	N(50) CR(50), TM(50)					N(50), CR(25), TM(50)		
			Sections	A(50)	N(50) CR(50), TM(50) AR*(25)					Not applicable		
		Al alone or with Ti	Plates	A(50)	AR*(25)		Not applicable					
			Sections	A(50)	N(50) CR(50), TM(50) AR*(25)					Not applicable		
D40	Killed and fine grain treated	Any	Plates	N(50) CR(50) TM(50)					N(50) TM(50) QT(Each length as heat treated)			
			Sections	N(50) CR(50) TM(50)					Not applicable			
E32 E36	Killed and fine grain treated	Any	Plates	N(Each piece) TM(Each piece)								
			Sections	N(25) TM(25) AR*(15), CR*(15)							Not applicable	
E40	Killed and fine grain treated	Any	Plates	N(Each piece) TM(Each piece) QT(Each length as heat treated)					N (Each piece) TM(Each piece) QT(Each length as heat treated)			
			Sections	N(25) TM(25) QT(25)					Not applicable			

W11

(cont)

Table 9 Required condition of supply and number of impact tests for higher strength steels (cont'd)

Grade	Deoxidation Practice	Grain Refining Elements	Products	Condition of supply (Batch for Impact Tests (1)(2))								
				Thickness (mm)								
				10	12.5	20	25	30	35	40	50	100
F32 F36	Killed and fine grain treated	Any	Plates	N(Each piece) TM(Each piece) QT(Each length as heat treated)							N(Each piece) TM(Each piece) QT(Each length as heat treated)	
			Sections	N(25) TM(25) QT(25) CR*(15)							Not applicable	
F40	Killed and fine grain treated	Any	Plates	N(Each piece) TM(Each piece) QT (Each length as heat treated)							N(Each piece) TM(Each piece) QT (Each length as heat treated)	
			Sections	N(25) TM(25) QT(25)							Not applicable	

Remarks:

(1) Condition of Supply

- A - Any
- N - Normalized Condition
- CR - Controlled Rolled Condition
- TM - Thermo-Mechanical Rolling
- QT - Quenched and Tempered Condition
- AR* - As Rolled Condition subject to the special approval of the Classification Society
- CR* - Controlled Rolled Condition subject to the special approval of the Classification Society

(2) Number of Impact Tests

One set of impact tests is to be taken from each batch of the "specified weight" in () or fraction thereof.

For grades A32 and A36 steels a relaxation in the number of impact tests may be permitted. (See Note(3) of Table 7.)

Appendix A. Manufacturing Approval Scheme of Hull Structural Steels**A1. Manufacturing Approval Scheme of Semi Finished Products for Hull Structural Steels****1. Scope of application**

This document specifies, as given in W11.2.1, the scheme for the approval of the manufacturing process of semi-finished products such as ingots, slabs, blooms and billets for the structural steels.

The manufacturing approval scheme is valid for verifying the manufacturer's capability to provide satisfactory products stably under effective process and production controls in which is required in W11.2.2.

2. Approval application**2.1 Documents to be submitted**

The manufacturer has to submit to the Society, request of approval, proposed approval test program (see 3.1) and general information relevant to:

- a) Name and site address of the manufacturer, location of the workshops, general indications relevant to the background, dimension of the works, estimated total annual production of finished products for shipbuilding and for other applications, as deemed useful.
- b) Organization and quality:
 - organizational chart
 - staff employed
 - staff employed and organization of the quality control department
 - qualification of the personnel involved in activities related to the quality of the products
 - certification of compliance of the quality system with ISO 9001 or 9002, if any
 - approval certificates already granted by other Classification Societies, if any
- c) Manufacturing facilities
 - flow chart of the manufacturing process
 - origin and storage of raw materials
 - storage of finished products
 - equipment for systematic control during fabrication
- d) Details of inspections and quality control facilities
 - details of system used for identification of materials at the different stages of manufacturing
 - equipment for chemical analyses and relevant calibration procedures
 - list of quality control procedures
- e) Type of products (ingots, slabs, blooms, billets); types of steel (normal or higher strength), range of thickness and aim material properties as follows:
 - range of chemical composition and aim analyses, including grain refining, micro alloying and residual elements, for the various grades of steel; if the range of chemical

W11

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composition depends on thickness and supply condition, the different ranges are to be specified, as appropriate

- aim maximum carbon equivalent according to IIW formula
- aim maximum Pcm content for higher strength grades with low carbon content $C < 0.13 \%$
- production statistics of the chemical composition and, if available at rolling mills, mechanical properties (ReH, Rm, A% and KV). The statistics are intended to demonstrate the capability to manufacture the steel products in accordance with the requirements.

f) Steelmaking

- steel making process and capacity of furnace/s or converter/s
- raw material used
- deoxidation and alloying practice
- desulphurisation and vacuum degassing installations, if any
- casting methods: ingot or continuous casting. In the case of continuous casting, information relevant to type of casting machine, teeming practice, methods to prevent re-oxidation, inclusions and segregation control, presence of electromagnetic stirring, soft reduction, etc., is to be provided as appropriate.
- ingot or slab size and weight
- ingot or slab treatment: scarfing and discarding procedures

g) Approval already granted by other Classification Societies and documentation of approval tests performed.

2.2 Documents to be submitted for changing the approval conditions

The manufacturer has to submit to the Society the documents required in 2.1 together with the request of changing the approval conditions, in the case of the following a) through c):

- a) Change of the manufacturing process (steel making process, casting method, steel making plant, caster)
- b) Change of the thickness range (dimension)
- c) Change of the chemical composition, added element, etc.

However, where the documents are duplicated by the ones at the previous approval for the same type of product, part or all of the documents may be omitted except the approval test program (see 3.1).

3. Approval tests

3.1 Extent of the approval tests

The extent of the test program is specified in 3.6, it may be modified on the basis of the preliminary information submitted by the manufacturer.

In particular a reduction of the indicated number of casts, product thicknesses and types to be tested or complete suppression of the approval tests may be accepted by the Society taking into account:

- a) Approval already granted by other Classification Societies and documentation of approval tests performed.
- b) Types of steel to be approved and availability of long term statistic results of chemical properties and of mechanical tests performed on rolled products.

W11
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c) Change of the approval conditions.

On the other hand, an increase of the number of casts and thicknesses to be tested may be required in the case of newly developed types of steel or manufacturing processes.

3.2 Approval test program

Where the number of tests differs from those shown in 3.6, the program is to be confirmed by the Society before the tests are carried out.

3.3 Approval survey

The approval tests are to be witnessed by the Surveyor at the manufacturer's plant and the execution of the plant inspection in operation may be required by the Surveyor during the visit for the approval.

If the testing facilities are not available at the works, the tests are to be carried out at recognized laboratories.

3.4 Selection of the test product

For each type of steel and for each manufacturing process (e.g. steel making, casting), one test product with the maximum thickness and one test product with the minimum thickness to be approved are in general to be selected for each kind of product (ingots, slabs, blooms/billets).

The selection of the casts for the test product is to be based on the typical chemical composition, with particular regard to the specified Ceq or Pcm values and grain refining micro-alloying additions.

3.5 Position of the test samples

The test samples are to be taken, unless otherwise agreed, from the product (slabs, blooms, billets) corresponding to the top of the ingot, or, in the case of continuous casting, a random sample.

3.6 Tests on base material**3.6.1 Type of tests**

The tests to be carried out for the approval of the manufacturing process of semi-finished products are:

- Chemical analysis. The analysis is to be complete and is to include micro alloying elements.
- Sulphur prints.

In addition, for initial approval and for any upgrade of the approval, the Society will require full tests indicated in Appendix A2.3 to be performed at rolling mill on the minimum thickness semi finished product.

In case of a multi-caster work, full tests on finished products shall be carried out for one caster and reduced tests (chemical analysis and sulphur print) for the others. The selection of the caster shall be based on the technical characteristics of the casters to be evaluated on

W11
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case by case basis to be performed at rolling mill on products manufactured from the minimum thickness semi finished product.

3.6.2 Test specimens and testing procedure

The following tests and procedures apply:

a) Chemical analyses

Both the ladle and product analyses are to be reported. In general the content of the following elements is to be checked: C, Mn, Si, P, S, Ni, Cr, Mo, Al, N, Nb, V, Cu, As, Sn, Ti and, for steel manufactured from electric or open-hearth furnace, Sb and B.

b) Sulphur prints are to be taken from product edges which are perpendicular to the axis of the ingot or slab. These sulphur prints are to be approximately 600 mm long taken from the centre of the edge selected, i.e. on the ingot centreline, and are to include the full product thickness.**4. Results**

All the results, which are in any case to comply with the requirements of the Rules, are evaluated for the approval; depending on the results, particular limitations or testing conditions, as deemed appropriate, may be specified in the approval document.

All the information required under Appendix A2.2, applicable to the products submitted to the tests, is to be collected by the manufacturer and put in the dossier which will include all the results of the tests and operation records relevant to steel making, casting and, when applicable, rolling and heat treatment of the test products.

5. Certification**5.1 Approval**

Upon satisfactory completion of the survey, approval is granted by the Society.

On the approval certificate the following information is to be stated:

- Type of products (ingots, slabs, blooms, billets)
- Steelmaking and casting processes
- Thickness range of the semi-finished products
- Types of steel (normal or higher strength)

It is also to be indicated that the individual users of the semi finished products are to be approved for the manufacturing process of the specific grade of rolled steel products they are going to manufacture with those semi finished products.

5.2 List of approved manufacturers

The approved manufacturers are entered in a list containing the types of steel and the main conditions of approval.

W11
(cont)**6. Renewal of approval**

The validity of the approval is to be a maximum of five years.

Renewal can be carried out by an audit and assessment on the result of satisfactory survey during the period*. Where for operational reasons, the renewal audit falls outside the period of approval, the manufacturer will still be considered as approved if agreement to this audit date is made within the original period of approval, in this instance if successful, the extension of approval will be back dated to the original renewal date.

Manufacturers who have not produced the approved grades and products during the period between renewals may be required to either carry out approval tests or, on the basis of results of production of similar grades of products, at the discretion of the Society, be re-approved.

7. Reconsideration of the approval

During the period of validity the approval may be reconsidered in the following cases:

- a) in service failures, traceable to product quality
- b) non conformity of the product revealed during fabrication and construction
- c) discovered failure of the Manufacturer's quality system
- d) changes brought by the Manufacturer, without preliminary agreement of the Society, to the extent of the approval defined at the time of the approval
- e) evidence of major non conformities during testing of the products.

* The provision for renewal of approval is also to be applied to all grades and products which were approved by the Society prior to an implementation of revision 4 of this UR W 11 regardless of the validity of certificate in existing approvals. Such renewal is to be completed within five years after the revision 4 becomes effective.

W11
(cont)**A2. Manufacturing Approval Scheme of Hull Structural Steels****1. Scope of application**

This document specifies, as given in W11.2.1, the scheme for the approval of the manufacturing process of normal and higher strength hull structural steels, ~~and also applies to the approval of semi-finished products such as slabs, blooms and billets for the structural steels.~~

The manufacturing approval scheme is valid for verifying the manufacturer's capability to provide satisfactory products stably under effective process and production controls in operation including programmed rolling, which is required in W11.2.2 and W11.3.3.

2. Approval application**2.1 Documents to be submitted**

The manufacturer has to submit to the Society, request of approval, proposed approval test program (see 3.1) and general information relevant to:

- a) Name and site address of the manufacturer, location of the workshops, general indications relevant to the background, dimension of the works, estimated total annual production of finished products for shipbuilding and for other applications, as deemed useful.
- b) Organization and quality:
 - organizational chart
 - staff employed
 - staff employed and organization of the quality control department
 - qualification of the personnel involved in activities related to the quality of the products
 - certification of compliance of the quality system with ISO 9001 or 9002, if any
 - approval certificates already granted by other Classification Societies, if any
- c) Manufacturing facilities
 - flow chart of the manufacturing process
 - origin and storage of raw materials
 - storage of finished products
 - equipment for systematic control during fabrication
- d) Details of inspections and quality control facilities
 - details of system used for identification of materials at the different stages of manufacturing
 - equipment for mechanical tests, chemical analyses and metallography and relevant calibration procedures
 - equipment for non destructive examinations
 - list of quality control procedures
- e) Type of products (plates, sections, coils), grades of steel, range of thickness and aim material properties as follows:
 - range of chemical composition and aim analyses, including grain refining, micro alloying and residual elements, for the various grades of steel; if the range of chemical composition depends on thickness and supply condition, the different ranges are to be specified, as appropriate

W11

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- aim maximum carbon equivalent according to IIW formula
 - aim maximum Pcm content for higher strength grades with low carbon content $C < 0.13 \%$
 - production statistics of the chemical composition and mechanical properties (ReH, Rm, A% and KV). The statistics are intended to demonstrate the capability to manufacture the steel products in accordance with the requirements.
- f) Steelmaking
- steel making process and capacity of furnace/s or converter/s
 - raw material used
 - deoxidation and alloying practice
 - desulphurisation and vacuum degassing installations, if any
 - casting methods: ingot or continuous casting. In the case of continuous casting, information relevant to type of casting machine, teeming practice, methods to prevent re-oxidation, inclusions and segregation control, presence of electromagnetic stirring, soft reduction, etc., is to be provided as appropriate.
 - ingot or slab size and weight
 - ingot or slab treatment: scarfing and discarding procedures
- g) Reheating and rolling
- type of furnace and treatment parameters
 - rolling: reduction ratio of slab/bloom/billet to finished product thickness, rolling and finishing temperatures
 - descaling treatment during rolling
 - capacity of the rolling stands
- h) Heat treatment
- type of furnaces, heat treatment parameters and their relevant records
 - accuracy and calibration of temperature control devices
- i) Programmed rolling
- For products delivered in the controlled rolling (CR) or thermo-mechanical rolling (TM) condition, the following additional information on the programmed rolling schedules is to be given:
- description of the rolling process
 - normalizing temperature, re-crystallization temperature and Ar3 temperature and the methods used to determine them
 - control standards for typical rolling parameters used for the different thickness and grades of steel (temperature and thickness at the beginning and at the end of the passes, interval between passes, reduction ratio, temperature range and cooling speed of accelerated cooling, if any) and relevant method of control
 - calibration of the control equipment
- j) Recommendations for working and welding in particular for products delivered in the CR or TM condition
- cold and hot working recommendations if needed in addition to the normal practice used in the shipyards and workshops
 - minimum and maximum heat input if different from the ones usually used in the shipyards and workshops (15 - 50 kJ/cm)
- k) Where any part of the manufacturing process is assigned to other companies or other manufacturing plants, additional information required by the Society is to be included.
- l) ~~For the approval of the semi-finished products such as slabs, blooms and billets, the above information a) through f) is to be given.~~

W11

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Approval already granted by other Classification Societies and documentation of approval tests performed.

2.2 Documents to be submitted for changing the approval conditions

The manufacturer has to submit to the Society the documents required in 2.1 together with the request of changing the approval conditions, in the case of the following a) through e) as applicable:

- a) Change of the manufacturing process (steel making, casting, rolling and heat treatment)
- b) Change of the maximum thickness (dimension)
- c) Change of the chemical composition, added element, etc.
- d) Subcontracting the rolling, heat treatment, etc.
- e) Use of the slabs, blooms and billets manufactured by ~~other~~ companies ~~which are not approved~~ other than the ones verified in the approval tests.

However, where the documents are duplicated by the ones at the previous approval for the same type of product, part or all of the documents may be omitted except the approval test program (see 3.1).

3. Approval tests

3.1 Extent of the approval tests

The extent of the test program is specified in 3.6 and 3.7; it may be modified on the basis of the preliminary information submitted by the manufacturer.

In particular a reduction of the indicated number of casts, steel plate thicknesses and grades to be tested or complete suppression of the approval tests may be accepted by the Society taking into account:

- a) Approval already granted by other Classification Societies and documentation of approval tests performed
- b) Grades of steel to be approved and availability of long term statistic results of chemical and mechanical properties
- c) Approval for any grade of steel also covers approval for any lower grade in the same strength level, provided that the aim analyses, method of manufacture and condition of supply are similar.
- d) For higher tensile steels, approval of one strength level covers the approval of the strength level immediately below, provided the steelmaking process, deoxidation and fine grain practice, casting method and condition of supply are the same.
- e) Change of the approval conditions
- f) ~~Approval of the semi-finished products such as slabs, blooms and billets.~~

On the other hand, an increase of the number of casts and thicknesses to be tested may be required in the case of newly developed types of steel or manufacturing processes.

In case of multi-source slabs or changing of slab manufacturer, the rolled steel manufacturer is required to obtain the approval of the manufacturing process of rolled steels using the slabs from each slab manufacturer and to conduct approval tests in accordance with 3.6 and 3.7. A reduction or complete suppression of the approval tests may be considered by the Society taking into account previous approval as follows:

W11
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- the rolled steel manufacturer has already been approved for the manufacturing process using other semi finished products characterized by the same thickness, steel grade, grain refining and micro-alloying elements, steel making and casting process;
- the semi finished products manufacturer has been approved for the complete manufacturing process with the same conditions (steelmaking, casting, rolling and heat treatment) for the same steel types.

3.2 Approval test program

Where the number of tests differs from those shown in 3.6 and 3.7, the program is to be confirmed by the Society before the tests are carried out.

3.3 Approval survey

The approval tests are to be witnessed by the Surveyor at the manufacturer's plant and the execution of the plant inspection in operation may be required by the Surveyor during the visit for the approval.

If the testing facilities are not available at the works, the tests are to be carried out at recognised laboratories.

3.4 Selection of the test product

For each grade of steel and for each manufacturing process (e.g. steel making, casting, rolling and condition of supply), one test product with the maximum thickness (dimension) to be approved is in general to be selected for each kind of product.

In addition, for initial approval, the Society will require selection of one test product of average thickness.

The selection of the casts for the test product is to be based on the typical chemical composition, with particular regard to the specified Ceq or Pcm values and grain refining micro-alloying additions.

3.5 Position of the test samples

The test samples are to be taken, unless otherwise agreed, from the product (plate, flat, section, bar) corresponding to the top of the ingot, or, in the case of continuous casting, a random sample.

The position of the samples to be taken in the length of the rolled product, "piece" defined in W11.11.1(a), (top and/or bottom of the piece) and the direction of the test specimens with respect to the final direction of rolling of the material are indicated in Table 1.

The position of the samples in the width of the product is to be in compliance with W11.11.2(d).

3.6 Tests on base material**3.6.1 Type of tests**

The tests to be carried out are indicated in the following Table 1.

Table 1 Tests on base material

Type of test	Position of the samples and direction of the test specimens ⁽¹⁾	Remarks
Tensile test	Top and bottom transverse ⁽²⁾	ReH, Rm, A ₅ (%), RA(%) are to be reported
Tensile test (stress relieved) only for TM steels	Top and bottom transverse ⁽²⁾	Stress relieving at 600 °C (2 min/mm with minimum 1 hour)
Impact tests ⁽³⁾ on non aged specimens for grades:	Top and bottom - longitudinal	Testing temperature (°C)
A, B, A32, A36, A40		+20 0 -20
D, D32, D36, D40		0 -20 -40
E, E32, E36, E40		0 -20 -40 -60
F32, F36, F40		-20 -40 -60 -80
A, B, A32, A36, A40		+20 0 -20
D, D32, D36, D40		0 -20 -40
E, E32, E36, E40		-20 -40 -60
F32, F36, F40	-40 -60 -80	
Impact test ⁽³⁾ on strain aged specimens ⁽⁵⁾ for grades:	Top - transverse ⁽⁴⁾	Testing temperature (°C)
A32, A36, A40		+20 0 -20
D, D32, D36, D40		0 -20 -40
E, E32, E36, E40		-20 -40 -60
F32, F36, F40		-40 -60 -80
Impact test ⁽³⁾ on strain aged specimens ⁽⁵⁾ for grades:	Top - longitudinal	Testing temperature (°C)
A32, A36, A40		+20 0 -20
D, D32, D36, D40		0 -20 -40
E, E32, E36, E40		-20 -40 -60
F32, F36, F40		-40 -60 -80
Chemical analyses ⁽⁶⁾	Top	Complete analyses including micro alloying elements
Sulphur prints	Top	
Micro examination	Top	
Grain size determination	Top	only for fine grain steels
Drop weight test ⁽⁴⁾	Top	only for grades E, E32, E36, E40, F32, F36, F40
Through thickness tensile tests	Top and bottom	only for grades with improved through thickness properties
1) For hot rolled strips see 3.6.2. 2) Longitudinal direction for sections and plates having width less than 600 mm. 3) One set of 3 Charpy V-notch impact specimens is required for each impact test. 4) Not required for sections and plates having width less than 600 mm. 5) Deformation 5% + 1 hour at 250°C. 6) Besides product analyses, ladle analyses are required.		

3.6.2 Test specimens and testing procedure

The test specimens and testing procedures are to be, as a rule, in accordance with W2.

In particular the following applies:

a) Tensile test

- for plates made from hot rolled strip one additional tensile specimen is to be taken from the middle of the strip constituting the coil.
- for plates having thickness higher than 40 mm, when the capacity of the available testing machine is insufficient to allow the use of test specimens of full thickness, multiple flat specimens, representing collectively the full thickness, can be used. Alternatively two round specimens with the axis located at one quarter and at mid-thickness can be taken.

W11

(cont)

- b) Impact test
- for plates made from hot rolled strip one additional set of impact specimens is to be taken from the middle of the strip constituting the coil.
 - for plates having thickness higher than 40 mm one additional set of impact specimens is to be taken with the axis located at mid-thickness.
 - in addition to the determination of the energy value, also the lateral expansion and the percentage crystallinity are to be reported.
- c) Chemical analyses
Both the ladle and product analyses are to be reported. The material for the product analyses should be taken from the tensile test specimen. In general the content of the following elements is to be checked: C, Mn, Si, P, S, Ni, Cr, Mo, Al, N, Nb, V, Cu, As, Sn, Ti and, for steel manufactured from electric or open-hearth furnace, Sb and B.
- d) Sulphur prints are to be taken from plate edges which are perpendicular to the axis of the ingot or slab. These sulphur prints are to be approximately 600 mm long taken from the centre of the edge selected, i.e. on the ingot centreline, and are to include the full plate thickness.
- e) Micrographic examination: the micrographs are to be representative of the full thickness. For thick products in general at least three examinations are to be made at surface, one quarter and mid-thickness of the product.
- All photomicrographs are to be taken at x100 magnification and where ferrite grain size exceeds ASTM 10, additionally at x500 magnification. Ferrite grain size should be determined for each photomicrograph.
- f) Drop weight test: the test is to be performed in accordance with ASTM E208. The NDTT is to be determined and photographs of the tested specimens are to be taken and enclosed with the test report.
- g) Through thickness tensile test: the test is to be performed in accordance with W14. The test results are to be in accordance, where applicable, with the requirements specified for the different steel grades in W11.

3.6.3 Other tests

Additional tests such as CTOD test, large scale brittle fracture tests (Double Tension test, ESSO test, Deep Notch test, etc.) or other tests may be required in the case of newly developed type of steel, outside the scope of W11, or when deemed necessary by the Society.

3.7 Weldability tests

3.7.1 General

Weldability tests are required for plates and are to be carried out on samples of the thickest plate. Tests are required for normal strength grade E and for higher strength steels.

3.7.2 Preparation and welding of the test assemblies

The following tests are in general required:

- a) 1 butt weld test assembly welded with a heat input approximately 15 kJ/cm

W11
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- b) 1 butt weld test assembly welded with a heat input approximately 50 kJ/cm.

The butt weld test assemblies are to be prepared with the weld seam transverse to the plate rolling direction, so that impact specimens will result in the longitudinal direction.

The bevel preparation should be preferably 1/2V or K.

The welding procedure should be as far as possible in accordance with the normal welding practice used at the yards for the type of steel in question.

The welding parameters including consumables designation and diameter, pre-heating temperatures, interpass temperatures, heat input, number of passes, etc. are to be reported.

3.7.3 Type of tests

From the test assemblies the following test specimens are to be taken:

- a) 1 cross weld tensile test
- b) a set of 3 Charpy V-notch impact specimens transverse to the weld with the notch located at the fusion line and at a distance 2, 5 and minimum 20 mm from the fusion line. The fusion boundary is to be identified by etching the specimens with a suitable reagent. The test temperature is to be the one prescribed for the testing of the steel grade in question.
- c) Hardness tests HV 5 across the weldment. The indentations are to be made along a 1 mm transverse line beneath the plate surface on both the face side and the root side of the weld as follows:
- Fusion line
 - HAZ: at each 0.7 mm from fusion line into unaffected base material (6 to 7 minimum measurements for each HAZ)

The maximum hardness value should not be higher than 350 HV.

A sketch of the weld joint depicting groove dimensions, number of passes, hardness indentations should be attached to the test report together with photomicrographs of the weld cross section.

3.7.4 Other tests

Additional tests such as cold cracking tests (CTS, Cruciform, Implant, Tekken, Bead-on plate), CTOD, or other tests may be required in the case of newly developed type of steel, outside the scope of W11, or when deemed necessary by the Society.

4. Results

All the results, which are in any case to comply with the requirements of the Rules, are evaluated for the approval; depending on the results, particular limitations or testing conditions, as deemed appropriate, may be specified in the approval document.

All the information required under [Appendix 2.2](#), applicable to the products submitted to the tests, is to be collected by the manufacturer and put in the dossier which will include all the results of the tests and operation records relevant to steel making, casting, rolling and heat treatment of the test products.

W11
(cont)**5. Certification****5.1 Approval**

Upon satisfactory completion of the survey, approval is granted by the Society.

5.2 List of approved manufacturers

The approved manufacturers are entered in a list containing the types of steel and the main conditions of approval.

6. Renewal of approval

The validity of the approval is to be a maximum of five years.

Renewal can be carried out by an audit and assessment on the result of satisfactory survey during the period.*

Where for operational reasons, the renewal audit falls outside the period of approval, the manufacturer will still be considered as approved if agreement to this audit date is made within the original period of approval, in this instance if successful, the extension of approval will be back dated to the original renewal date.

Manufacturers who have not produced the approved grades and products during the period between renewals may be required to either carry out approval tests or, on the basis of results of production of similar grades of products, at the discretion of the Society, be reapproved.

7. Reconsideration of the approval

During the period of validity the approval may be reconsidered in the following cases:

- a) in service failures, traceable to product quality
- b) non conformity of the product revealed during fabrication and construction
- c) discovered failure of the Manufacturer's quality system
- d) changes brought by the Manufacturer, without preliminary agreement of the Society, to the extent of the approval defined at the time of the approval
- e) evidence of major non conformities during testing of the products.

Note:—* The provision for renewal of approval is also to be applied to all grades and products which were approved by the Society prior to an implementation of revision 4 of this UR W 11 regardless of the validity of certificate in existing approvals. Such renewal is to be completed within five years after the revision 4 becomes effective.

Appendix B. Approval scheme for manufacturer of hull structural steels intended for welding with high heat input**1. Scope**

This document specifies the weldability confirmation scheme of normal and higher strength hull structural steels stipulated in UR W11 intended for welding with high heat input over 50kJ/cm.

The weldability confirmation scheme is to be generally applied by manufacturer's option and valid for certifying that the steel has satisfactory weldability for high heat input welding concerned under testing conditions.

Demonstration of conformance to the requirements of this document approves a particular steel mill to manufacture grade of steel to the specific chemical composition range, melting practice, and processing practice for which conformance was established. The approval scheme does not apply to qualification of welding procedures to be undertaken by the shipyards.

2. Application of certification

The manufacturer is to submit to the Classification Society, request of certification, proposed weldability test program (see section 3.2) and technical documents relevant to:

- a) Outline of steel plate to be certified
 - grade
 - thickness range
 - deoxidation practice
 - fine grain practice
 - aim range of chemical composition
 - aim maximum Ceq and Pcm
 - production statistics of mechanical properties (tensile and Charpy V-notch impact tests), if any
- b) Manufacturing control points to prevent toughness deterioration in heat affected zone when welded with high heat input, relevant to chemical elements, steel making, casting, rolling, heat treatment etc.
- c) Welding control points to improve joint properties on strength and toughness, if any.

3. Confirmation tests**3.1 Range of certification**

Range of certification for steel grades is to be the following a) through e) unless otherwise agreed by the Classification Society:

- a) Approval tests on the lowest and highest toughness levels cover the intermediate toughness level.
- b) Approval tests on normal strength level cover that strength level only.

W11
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- c) For high tensile steels, approval tests on one strength level cover strength level immediately below.
- d) Tests may be carried out separately subject to the same manufacturing process.
- e) Certification and documentation of confirmation tests performed by other Classification Society may be accepted at the discretion of the Classification Society.

3.2 Weldability test program

Extent of the test program is specified in section 3.5 but it may be modified according to the contents of certification. In particular, additional test assemblies and/or test items may be required in the case of newly developed type of steel, welding consumable and welding method, or when deemed necessary by the Classification Society.

Where the content of tests differs from those specified in section 3.5, the program is to be confirmed by the Classification Society before the tests are carried out.

3.3 Test plate

Test plate is to be manufactured by a process approved by the Classification Society in accordance with the requirements of UR W11 Appendix A.

For each manufacturing process route, two test plates with different thickness are to be selected. The thicker plate (t) and thinner plate (less than or equal to $t/2$) are to be proposed by the manufacturer.

Small changes in manufacturing processing (e.g. within the TMCP process) may be considered for acceptance without testing, at the discretion of the Classification Society.

3.4 Test assembly

One butt weld assembly welded with heat input over 50kJ/cm is to be generally prepared with the weld axis transverse to the plate rolling direction.

Dimensions of the test assembly are to be amply sufficient to take all the required test specimens specified in section 3.5.

The welding procedures should be as far as possible in accordance with the normal practices applied at shipyards for the test plate concerned.

Welding process, welding position, welding consumable (manufacturer, brand, grade, diameter and shield gas) and welding parameters including bevel preparation, heat input, preheating temperatures, interpass temperatures, number of passes, etc. are to be reported.

3.5 Examinations and tests for the test assembly

The test assembly is to be examined and tested in accordance with the following a) through h) unless otherwise agreed by the Classification Society.

- a) Visual examination
Overall welded surface is to be uniform and free from injurious defects such as cracks, undercuts, overlaps, etc.

W11
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- b) Macroscopic test
One macroscopic photograph is to be representative of transverse section of the welded joint and is to show absence of cracks, lack of penetration, lack of fusion and other injurious defects.
- c) Microscopic test
Along mid-thickness line across transverse section of the weld, one micrograph with x100 magnification is to be taken at each position of the weld metal centreline, fusion line and at a distance 2, 5, 10 and minimum 20 mm from the fusion line. The test result is provided for information purpose only.
- d) Hardness test
Along two lines across transverse weld section 1 mm beneath plate surface on both face and root side of the weld, indentations by HV5 are to be made at weld metal centreline, fusion line and each 0.7 mm position from fusion line to unaffected base metal (minimum 6 to 7 measurements for each heat affected zone).

The maximum hardness value should not be higher than 350 HV.

- e) Transverse tensile test
Two transverse (cross weld) tensile specimens are to be taken from the test assembly. Test specimens and testing procedures are to comply with the requirements of UR W2.

The tensile strength is to be not less than the minimum required value for the grade of base metal.

- f) Bend test
Two transverse (cross weld) test specimens are to be taken from the test assembly and bent on a mandrel with diameter of quadruple specimen thickness. Bending angle is to be at least 120°. Test specimens are to comply with the requirements of UR W2.

For plate thickness up to 20 mm, one face-bend and one root-bend specimens or two side-bend specimens are to be taken. For plate thickness over 20 mm, two side-bend specimens are to be taken.

After testing, the test specimens shall not reveal any crack nor other open defect in any direction greater than 3 mm.

- g) Impact test
Charpy V-notch impact specimens (three specimens for one set) are to be taken within 2 mm below plate surface on face side of the weld with the notch perpendicular to the plate surface.

One set of the specimens transverse to the weld is to be taken with the notch located at the fusion line and at a distance 2, 5 and minimum 20 mm from the fusion line. The fusion boundary is to be identified by etching the specimens with a suitable reagent. The test temperature is to be the one prescribed for the testing of the steel grade in question.

For steel plate with thickness greater than 50 mm or one side welding for plate thickness greater than 20 mm, one additional set of the specimens is to be taken from the root side of the weld with the notch located at each the same position as for the face side.

The average impact energy at the specified test temperature is to comply with the Tables 6 or 7 of UR W11 depending on the steel grade and thickness. Only one individual value may be below the specified average value provided it is not less than 70% of that value.

W11
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Additional tests at the different testing temperatures may be required for evaluating the transition temperature curve of absorbed energy and percentage crystallinity at the discretion of the Classification Society.

- h) Other test
Additional tests such as wide-width tensile test, HAZ tensile test, cold cracking tests (CTS, Cruciform, Implant, Tekken, and Bead-on plate), CTOD or other tests should be required at the discretion of the Classification Society (see section 3.2).

4. Results

The manufacturer is to submit to the Classification Society the complete test report including all the results and required information relevant to the confirmation tests specified in section 3.

The contents of the test report are to be reviewed and evaluated by the Classification Society in accordance with this weldability confirmation scheme.

5. Certification

The Classification Society issues the certificate where the test report is found to be satisfactory.

The following information is generally required to be included on the certificate:

- a) Manufacturer
- b) Grade designation with notation of heat input (see section 6)
- c) Deoxidation practice
- d) Fine grain practice
- e) Condition of supply
- f) Plate thickness tested
- g) Welding process
- h) Welding consumable (manufacturer, brand, grade), if desired
- i) Actual heat input applied.

6. Grade designation

Upon issuance of the certificate, the notation indicating the value of heat input applied in the confirmation test may be added to the grade designation of the test plate, e.g. "E36-W300" (in the case of heat input 300 kJ/cm applied). The value of this notation is to be not less than 50 and every 10 added.

End of Document
