

CLASSIFICATION NOTES

Approval Scheme for the Manufacturing Process of Normal and Higher Strength Hull Structural Steels

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Approval Scheme for the Manufacturing Process of Normal and Higher Strength Hull Structural Steels

Scope of application

This document specifies, the scheme for the approval of the manufacturing process of normal and higher strength hull structural steels, including the manufacturing of semi-finished products such as slabs, blooms and billets for the structural steels to meet the requirements of para 1.2.1, ch.3, part 2 of the Main Rules.

Part 1 of this document specifies the scheme for the approval of the manufacturing process of semi-finished products such as ingots, slabs, blooms and billets for the structural steels.

Part 2 of this document addresses the requirement of approval of the manufacturing process of steels intended for welding with heat input in the range of 15 -50 kJ/cm.

Part 3 of this document addresses the additional weldability test requirements for approval of the manufacturing process of steels intended for welding with heat input greater than 50kJ/cm.

The purpose of the approval scheme is to verify the manufacturer's capability to provide satisfactory products consistently under effective process and production controls including programme of rolling, as required in Part 2, Chapter 3 of main Rules.

Part 1 : Manufacturing approval scheme of semi-finished products for hull structural steels

1. Approval application

1.1 Documents to be submitted

The manufacturer has to submit to IRS, request of approval, proposed approval test program (see 2.1) and general information relevant to:

- a) Name and site address of the manufacturer, location of the workshops, general indications relevant to the background, capacity 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
 - Number and qualification of personnel directly engaged in quality assurance, production and quality control
 - Certification of compliance of the quality system with ISO 9001 or 9002, if any
 - Approval of certificates already granted by other Classification Societies, if any.
- c) Manufacturing facilities
- Flow chart of the manufacturing process, including identification of critical hold points for quality control
 - 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 and traceability of raw materials and semi-finished products 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 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.
 - Maximum carbon equivalent according to IIW formula (Part 2, Ch 3, Sec. 3 of Main Rules)
 - Maximum cold cracking susceptibility (Pcm) content, for higher strength grades with low carbon content $C < 0.13\%$
 - Past 3 years production statistics of the chemical composition and, if available at rolling mills
 - Mechanical properties (UTS, % reduction in area, YS, HV, impact energy). The statistics are intended to demonstrate the capability to manufacture the steel products in accordance with the requirements.

f) Steel making :

- 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.

1.2 Documents to be submitted for changing the approval conditions

The manufacturer has to submit to IRS the documents required in 1.1 together with the request of changing the approval conditions, in case of any one or more of the following:

- a) Change in the manufacturing process (steel making process, casting method, steel making plant, caster)
- b) Change of thickness range
- c) Change in 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 of the approval test program (see 2.1).

2. Approval tests

2.1 Extent of the approval tests

The extent of the test program is specified in 2.6 and 2.7; 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, product thicknesses and types to be tested or complete waiver of the approval tests may be accepted by IRS 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.
- c) Change of the approval conditions

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

2.2 Approval test program

Where the number of tests differs from those shown in 2.6, the program is to be confirmed by IRS before the tests are carried out.

2.3 Approval survey

The approval tests are to be witnessed by the Surveyor at the manufacturer's plant and 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.

2.4 Selection of the test sample

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 C_{eq} or P_{cm} values and grain refining micro-alloying additions.

2.5 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.

2.6 Tests on base material

2.6.1 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, IRS will require full tests indicated in Part 2, Section 2 of this scheme 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 will be based on the technical characteristics of the casters to be evaluated on case by case basis.

2.6.2 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 center of the edge selected, i.e. on the ingot centerline and are to include the full product thickness.

3. 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 Part 2, Section 2 of this scheme 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.

4. Certification

4.1 Approval

Upon satisfactory completion of the survey, approval is given by IRS.

On the approval certificate the following information will be stated:

- Type of products (ingots, slabs, blooms, billets)
- Steel making 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.

4.2 List of approved manufacturers

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

5. Renewal of approval

The validity of the approval is at the maximum for five years.

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

Note : The provision for renewal of approval is also to be applied to all grades and products, which were approved by IRS prior to implementation of March, 2006 version of this Classification Notes, regardless of the validity of certificate in existing approval. Such renewal is to be completed by March, 2011.

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 result of production of similar grades of products, at the discretion of IRS, be re-approved.

6. 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 IRS, to the defined extent of the approval
- e) evidence of major non-conformities during testing of the products.

Part 2 : Approval of the manufacturing process of steels intended for welding with heat input in the range of 15 -50 kJ/cm

1. Approval application

1.1 Documents to be submitted

The manufacturer has to submit to IRS, the request for approval, proposed approval test program (see 2.1) and general information relevant to:

- a) Name and site address of the manufacturer, location of the workshops, general indications relevant to the background, capacity 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
 - Number and qualification of personnel directly engaged in Quality Assurance, production and quality control.
 - Certification of compliance of the quality system with ISO 9001:2000, if any.
 - Approval certificates already granted by other Classification Societies, if any.
- c) Manufacturing facilities :
 - flow chart of the manufacturing process, including identification of critical hold points for quality control.
 - origin and storage of raw materials
 - storage of finished products
 - Equipment for exercising control during fabrication
- d) Details of inspections and quality control facilities
 - Details of system used for identification and traceability of raw materials and products 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 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
- Maximum carbon equivalent according to IIW formula (Part 2, Ch 3, Sec. 3 of Main Rules)
- Maximum cold cracking susceptibility (Pcm) content, for higher strength grades with low carbon content $C < 0.13\%$
- Past 3 years record of chemical & mechanical properties (UTS, % reduction in area, YS, HV, impact energy). The statistical data is intended to demonstrate the capability to manufacture consistently the steel products in accordance with the requirements.

f) Steel making :

- 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, rolling tolerances.
- De-scaling treatment during rolling
- Capacity of the rolling stands

h) Heat treatment :

- Type of furnaces, heat treatment parameters and their relevant records of the past 3 years
- Accuracy and calibration of temperature control devices.

i) Programmed rolling:

For products delivered in the controlled rolled (CR) or thermo-mechanical rolled 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 upper critical temperature(Ar3) 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 subcontracted or is undertaken at other manufacturing plants, relevant details as above, for such work is to be included.

1.2 Documents to be submitted for changing the approval conditions

The manufacturer has to submit to IRS the documents required in 1.1 together with the request of changing the approval conditions, in case of any one or more of the following:

- a) Change in the manufacturing process (steel making, casting, rolling and heat treatment)
- b) Change in the maximum thickness produced.
- c) Change in the chemical composition, added element, etc
- d) Subcontracting the rolling, heat treatment, etc.
- e) Use of the slabs, blooms and billets manufactured by companies other than 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 of the approval test program (see 2.1)

2. Approval tests

2.1 Extent of the approval tests

The extent of the test program is specified in 2.6 and 2.7; it may be modified by IRS 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 waiver of the approval tests may be accepted by IRS 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 statistical 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 chemical analyses, method of manufacture and condition of supply are similar.
- d) For higher tensile steels, approval of one strength level also covers the approval of the steel of immediate lower level strength, provided the steel making process, deoxidation and fine grain practice, casting method and condition of supply are the same.
- e) Change of the approval conditions.

On the other hand, an increase of the number of casts and thicknesses may be required to be tested 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 2.6 and 2.7. A reduction or complete waiver of the approval tests may be considered by IRS taking into account previous approval as follows:

- 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 (steel making, casting, rolling and heat treatment) for the same steel types.

2.2 Approval test program

Where the number of tests differs from those shown in 2.6 and 2.7, the program is to be confirmed by IRS before the tests are carried out.

2.3 Approval survey

The approval tests are to be witnessed by the Surveyor at the manufacturer's plant. Plant inspection in operation will be required by the Surveyor during the visit for the approval towards verifying and confirming the data submitted by the manufacturer. If the testing facilities are not available at the works, the tests are to be carried out at recognized/approved laboratories in the presence of IRS Surveyor.

2.4 Selection of the test sample

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

In addition, for initial approval, IRS will require selection of one test sample 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.

2.5 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 along the length of the rolled product, as described in Pt. 2, Ch. 3, 1.6 of Main Rules, (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 Part 2, Ch. 3, 1.6.3 of Main Rules.

2.6 Tests on base material

2.6.1 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 - (see note 1)	Remarks			
Tensile test	Top and bottom - transverse (see note 2)	YS, UTS, A _s (%), %El are to be reported			
Tensile test (stress relieved) only for TM steels	Top and bottom - transverse (see note 2)	Stress relieving at 600 ⁰ 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 tests (3) on strain aged specimens (5) for grades:	Top - longitudinal	Testing temperature (°C)			
A, B, A32, A36, A40					
D, D32, D36, D40		+20	0	-20	
E, E32, E36, E40		0	-20	-40	
F32, F36, F40		-20	-40	-60	
		-40	-60	-80	
Chemical analyses (6)	Top	Complete analyses including micro alloying elements			

Sulphur prints		Refer IS:4163-1982, method for determining non-metallic inclusions or ASTM E-45
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
<ol style="list-style-type: none"> 1) For hot rolled strips see 2.6.2 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) Specimen with deformation 5% kept at 250⁰C for 1 hour. 6) Besides product analyses, ladle analyses are required. 		

2.6.2 Test specimens and testing procedure

The test specimens and testing procedures are to be, in general, in accordance with Pt 2, Ch.2 of Main Rules.

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 40mm, 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.

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 40mm 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 center of the edge selected, i.e. on the ingot centerline, 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 x 100 magnification and where ferrite grain size exceeds ASTM 10, additionally at x 500 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 Nil Ductility Transition Temperature of Ferritic Steels (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 Chapter 2, Part 3 of Main Rules.

The test results are to be in accordance, where applicable, with the requirements specified for the different steel grades in Chapter 3 of Part 2 of Main Rules.

2.6.3 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 Part 2 of Main rules.

2.7 Weldability tests

2.7.1 General

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

2.7.2 Preparation and welding of the test assemblies

The following tests are in general required:

- a) One butt weld test assembly welded with a heat input approximately 15 kJ/cm
- b) One 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 single V, double V or K.

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

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

2.7.3 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 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 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.

2.7.4 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 Chapter 3, Part 2 of Main Rules, or when deemed necessary by IRS.

3. 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 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.

4. Certification

4.1 Approval

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

4.2 List of approved manufacturers

The approved manufacturer's name is entered in a list containing the type of steel and the main conditions of approval.

5. Renewal of approval

The validity of the approval is at the maximum for five years.

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

Note: The provision for renewal of approval is also to be applied to all grades and products, which were approved by IRS prior to implementation of the March, 2006 version of this Classification notes regardless of the validity of certificate in existing approval. Such renewal is to be completed by March, 2011.

Where for operational reasons, the renewal audit is carried out 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 considered from 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 result of production of similar grades of products, at the discretion of IRS, be re-approved.

6. 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 IRS, to the defined extent of the approval.
- e) Evidence of major non-conformities during testing of the products.

Part 3 : Additional Weldability Confirmation Scheme for Hull Structural Steels intended for Welding with Heat Input > 50 [kJ/cm]

1. General

This part specifies the weldability confirmation scheme of normal and higher strength hull structural steels stipulated in Section 2 and Section 3 of Part 2, Chapter 3 of the Main Rules, intended for welding with high heat input, over 50 [kJ/cm].

This weldability scheme is applicable only when the steel manufacturer is intending to demonstrate that the steel can be welded with high heat input under controlled conditions, specified and maintained during weldability test.

Compliance to the requirements given in this Part 2 of Classification Notes qualifies a steel mill to manufacture a particular grade of steel having specific chemical composition by following melting practices suitable for welding steel with high heat input. The manufacturer has to also comply with the requirements specified in Part 1 of this classification notes. This approval scheme is not intended for qualifying welding procedure adopted by the shipyard.

IRS at its discretion may accept certification and documentation of confirmation tests performed by other Classification society.

2. Application of certification

The manufacturer is to submit to IRS, request for certification, proposed weldability test program (see section 3.2) and technical documents relevant to:

- a) Outline of steel plate to be certified under the scheme
 - Grade of steel
 - thickness range for which approval is requested
 - deoxidation practice
 - fine grain practice
 - intended range of chemical composition
 - intended maximum carbon equivalent (Ceq) and cold cracking susceptibility (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) Control to be exercised, if any, during welding, to improve strength and toughness properties of weld joint.

3. Confirmation tests

3.1 Range of certification

Range of certification for steel grades will be based on the following unless otherwise agreed by IRS:

- 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.
- c) For high tensile steels, approval tests on one strength level cover strength level immediately below.

3.2 Weldability test program

Extent of the test program is specified in section 3.5, but it may be modified according to the requirements 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 IRS.

Where the number and type of tests differ from those specified in section 3.5, the test program is to be confirmed by IRS before the tests are carried out.

3.3 Test plate

Test plate is to be manufactured by a process approved by IRS in accordance with the requirements of Part 1 of this classification notes.

For each manufacturing process, two test plates with different thickness are to be selected and the plate thicknesses are to be proposed by the manufacturer (thicker plate of thickness t and thinner plate of thickness $t/2$).

3.4 Test assembly

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

Dimensions of the test assembly are to be 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 recorded.

3.5 Examinations and tests for the test assembly

The test assembly is to be subjected to following tests, unless otherwise agreed by IRS.

a) Visual examination

Welded joint is to be uniform and free from injurious defects such as cracks, undercuts, overlaps, etc.

b) Macroscopic test

A transverse section of the weld joint is to be subjected to macro examination and the specimen is to be free from cracks, lack of penetration, lack of fusion and other defects such as porosities, slag etc.

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 centerline, fusion line and at a distance 2, 5, 10 and 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 centerline, 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 tensile specimens across the weld are to be taken from the test assembly. Test specimens and testing procedures are to comply with the requirements of Part 2, Chapter 2 of the Main Rules.

f) Bend test

Two transverse test specimens are to be taken from the test assembly and bent on a mandrel with diameter of 4 times the specimen thickness. Bending angle is to be at least 120°. Test specimens are to comply with the requirements of Part 2, Chapter 2 of the Main Rules and number of bend test specimens are to be as under.

<u>Plate thickness</u>	<u>Number of bend test specimens</u>
Upto and including 20 mm	1 face bend 1 root bend OR 2 side bends
> 20 mm	2 side bends.

Test specimens shall not reveal any crack or other open defect of size greater than 3 [mm] in any direction.

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 notch located at the fusion line and at a distance 2, 5 and 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 for plate thickness greater than 20 [mm] with welding from single side, one additional set of the specimens is to be taken from the root side of the weld with the notch located at the same position as for the face side.

The average impact energy at the specified test temperature is to comply with the Tables 2.4.1 or 3.4.1 of Part 2, Chapter 3 of Main Rules 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.

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

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), Crack Tip Opening Deflection or other tests may be required at the discretion of IRS (see section 3.2).

4. Results

The manufacturer is to submit to IRS the complete test report including all the results and required information relevant to the confirmation tests specified in section 3, for review and evaluation.

5. Certification

A certificate will be issued, if the test results are found to be satisfactory.

The following information will 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 conformation test would be added to the grade designation of the test plate, e.g. “E36-W300” if heat input is 300 [kJ/cm]. Heat input will be indicated only when it is more than 50 [kJ/cm] and in steps of 10.