GUIDANCE NOTES
GD030-2025

INTERNATIONAL SHIP CLASSIFICATION

GUIDELINES FOR WELDING INSPECTION OF INTELLIGENT MANUFACTURING OF SHIPS

2025

Effective from 1 January, 2026

CONTENTS

CHAPTER ONE GENERAL PROVISIONS

1.1 Objectives

1.1.1 The Guidelines provide guidance on the certification of the capabilities of intelligent welding equipment for ships and the inspection of on-site welding quality, intending to promote the application of intelligent welding equipment in the construction of ships and offshore engineering.

1.1.2 The certification of the capabilities of intelligent welding equipment and the inspection of on-site welding in the Guidelines are recommendatory requirements.

1.2 Scope of Application

1.2.1 The Guidelines are applicable to the following inspections of intelligent welding equipment:

(1) Certification of welding capability of intelligent welding equipment;

(2) Verification of welding operation of intelligent welding equipment;

(3) Approval of welding procedure database;

(4) Inspection of application of intelligent welding equipment.

1.2.2 The Guidelines are applicable to arc welding equipment for steel hull structures. Welding equipment for other materials and procedures may refer to the Guidelines, and the specific implementation is to be determined by the applicant and International Ship Classification (ISC).

1.3 Definitions

1.3.1 Intelligent welding equipment: is a modern device with the ability to execute, perceive and make decisions to efficiently, precisely and stably carry out welding based on technologies such as sensing, automatic control, robotics, artificial intelligence, big data, the Internet of Things, etc..

1.3.2 Welding procedure database: is a systematic collection of welding procedure data, used for storing and managing complete procedure information including base materials, welding consumables, welding methods, welding positions, type of joints, and other procedure parameters. The core function of this database lies in that the procedure parameters it stores can be directly connected to and drive welding equipment to complete actual welding operations, thereby ensuring the accuracy and consistency of procedure execution.

CHAPTER TWO CERTIFICATION OF CAPABILITY OF INTELLIGENT WELDING EQUIPMENT

2.1 General Provisions for Certification of Capability of Intelligent Welding Equipment

2.1.1 Certification of capability of intelligent welding equipment and verification of welding operation of intelligent welding equipment are generally to follow the process in Figure 2.1.1. Approval of welding procedure database is carried out separately.

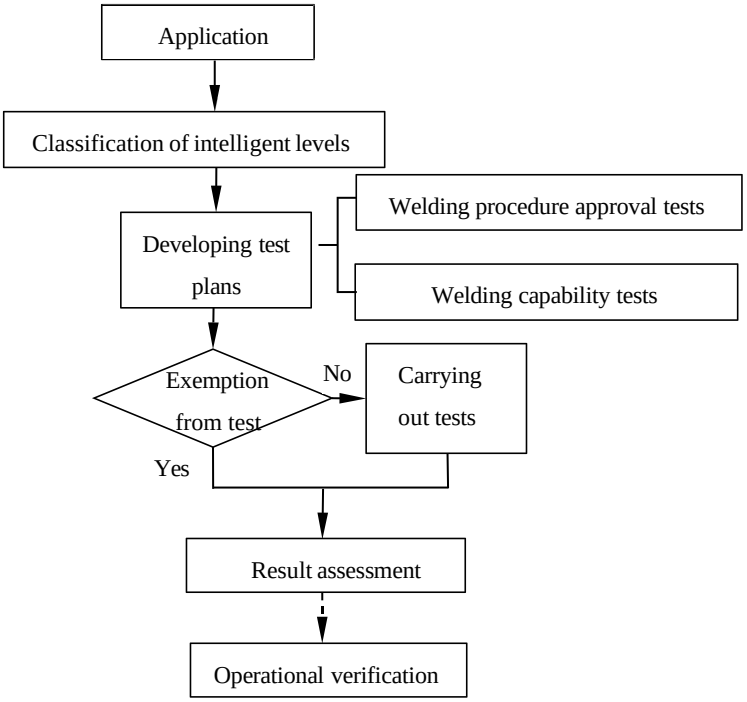


Figure 2.1.1 Process of Certification

2.1.2 When the applicant applies for the certification of capability of intelligent welding equipment, the basic components of the intelligent welding equipment generally are to meet the following requirements and relevant materials are to be provided for information:

(1) Arc welding equipment such as welding power sources and wire feeding devices comply with recognized relevant standards;

(2) Manipulator/robot equipment complies with recognized relevant standards;

(3) Sensing equipment and other equipment comply with the manufacturer's requirements or recognized relevant standards.

2.1.3 According to the intelligent level of welding equipment, it is classified into six levels from WL0 to WL5, as shown in Table 2.1.3. Among them, WL0 represents fully mechanized welding, while WL1 to WL5 represent automatic welding. The intelligent welding equipment mentioned in the Guidelines refers to WL1 to WL5, with WL5 being the highest level.

Classification of Intelligent Levels for Intelligent Welding Equipment Table 2.1.3

Item	Intelligent level	WL0	WL1	WL2	WL3	WL4	WL5
Execution capability	Mechanized movement of welding torches	√	√	√	√	√	√
	Automatic location of the welding torch (including automatic start point location and end point retraction)	—	—	√	√	√	√
	Automatic setting and adjustment of welding parameters (current, voltage, speed, etc)	—	√	√	√	√	√
Sensory capability	Welding parameters acquisition (current, voltage, speed, etc.)	—	√	√	√	√	√
	Visual scanning (groove scanning, workpiece scanning)	—	○	√	√	√	√
	Visual monitoring (weld pool monitoring)	—	—	○	○	○	√
	Sound sense	—	—	○	○	○	√
	Environmental sense (anti-collision)	—	—	○	○	√	√
Cognitive capability	Automatic modeling of welded structures (if applicable)	—	—	○	√	√	√
	Welding reference point identification	—	—	√	√	√	√
	Weld identification (identify welds by using scanning data, design data, parameter data, etc.) (if applicable)	—	—	√	√	√	√
	Groove modeling (groove modeling by scanning) (if applicable)	—	—	—	√	√	√
	Early warning of cognitive abilities	—	—	○	○	√	√
Decision-making capability	Welding parameters matching (match the welding parameters based on the identification results)	—	—	√	√	√	√
	Adaptive adjustment of welding parameters (if applicable)	—	—	—	○	○	√
	Automatic adjustment of torch posture (including the angle of the welding torch and the distance from the welding torch to workpiece)	—	—	√	√	√	√
	Automatic planning of welding sequence (if applicable)	—	—	√	√	√	√
	Automatic planning of weld pass sequence for	—	—	○	√	√	√

	multi-pass welding (if applicable)						
	Weld tracking (arc sensing/visual sensing)	—	√	√	√	√	√
	Visual inspection of welds	—	—	—	○	○	√
	Welding quality analysis and diagnosis (utilizing AI with welding process)	—	—	—	○	○	√
	Research and development of procedure of AI technology	—	—	○	○	○	√
Interactivity capability	Human-computer intelligent interaction (via voice and scene recognition)	—	—	—	—	—	○
	Multi-machine interaction (working in coordination by multiple welding equipment)	—	—	—	—	√	√
	Multi-device collaboration and integrated control (for continuous operation)	—	—	—	√	√	√
	Visualized data presentation and data output	—	—	○	○	√	√
	Data interconnection and interoperability (interact with data systems and other devices)	—	○	○	√	√	√
	Intelligence for operation and maintenance (equipment troubleshooting, remote interactive control, and establishment of equipment knowledge bases, etc.)	—	—	—	—	—	√
	Handling by cloud	—	—	—	—	—	√

Note: √ indicates required; ○ indicates optional; — indicates not applicable or no requirement; items marked "if applicable" must be met when the application scenario or weld type requires.

2.1.4 According to the intelligent levels in 2.1.3, Table 2.1.4 presents typical application examples of intelligent welding equipment at WL0 to WL5. The actual levels are to be determined specifically in accordance with the requirements of this Chapter.

Typical application examples of intelligent welding equipment Table 2.1.4

Level	Intelligent level	Welding operator	Typical application examples of equipment
WL0	No intelligence	Welding operators are required during welding process.	Conventional submerged arc welding; fillet welding trolley; electro-gas welding machine; automatic welding trolley, etc.
WL1	Assisted intelligence	Welding operators are required during welding process.	Collaborative welding robot; pipe welding machine; teaching programming welding robot.
WL2	Partial intelligence	Welding operators are required during welding process.	Collaborative welding robot with visual sensing.

WL3	Conditional intelligence	Welding operators are required under some circumstances.	Welding robots with certain cognitive and decision-making capability; industrial robot welding workstation; trackless autonomous crawling robot.
WL4	High intelligence	Welding operators are required to intervene under special circumstances.	Structural component welding line; ship assembly welding production line.
WL5	Full intelligence	No welding operator is required.	Fully intelligent welding.

2.1.5 According to 2.1.3 and 2.1.4, ISC is to preliminarily confirm the level of the intelligent welding equipment by the following methods:

(1) Materials submitted by the applicant;

(2) On-site audit by ISC.

2.1.6 Capability certification of intelligent welding equipment is to be carried out in accordance with the intelligent level required by the various determined levels, and the welding procedure approval tests as per 2.2 of this Chapter and the welding capability tests as per 2.3 of this Chapter are to be carried out respectively. Approval of welding procedure database is to be carried out as per 2.4 of this Chapter. Operation verification of intelligent welding equipment is to be carried out as per 2.5 of this Chapter.

2.1.7 If the intelligent welding equipment has been delivered and put into use at the user's site and relevant materials for the welding procedure approval tests and the welding capability tests are provided, the relevant tests can be exempted after audit by ISC. If the applicant has applied the welding procedure database and provided relevant materials for the test, the relevant tests can be exempted after audit by ISC.

2.1.8 If the tests or material evaluations as required in 2.1.6 of this Chapter show that the results meet the requirements of this Chapter, the capability certification certificate of the intelligent welding equipment may be issued. If the approval of the welding procedures database as per 2.4 of this Chapter is satisfactory, the approval certificate of the welding procedures database may be issued. If the operation verification test as per 2.5 of this Chapter is satisfactory, the operation verification certificate of the intelligent welding equipment may be issued.

2.1.9 The validity period of the capability certification certificate of the intelligent welding equipment and the operation verification certificate of the intelligent welding equipment obtained by the applicant is five years. During the validity period, the capability stated in the certificate is to be inspected in the third year. After the expiration of the certificate, the validity period can be extended for another five years upon inspection. The approval certificate of the welding procedures database has no validity period. ISC is to withdraw the obtained certificates under the following circumstances:

(1) The capability of the intelligent welding equipment decreases and does not meet the capability for obtaining certificates;

(2) The welding quality of the intelligent welding equipment has significantly decreased.

2.2 Welding Procedure Approval Tests

2.2.1 Typical test specimens within the range of capability of the intelligent welding equipment are to be selected for the welding procedure approval tests.

2.2.2 The test specimens for the welding procedure approval tests are to comply with the relevant requirements for automatic welding in Sections 2 and 3, Chapter 3, PART THREE of ISC Rules for Materials and Welding. The groove form and assembly of the test specimens are to fully consider the conditions during actual welding production.

2.2.3 The welding procedure approval tests are to be carried out in accordance with the requirements of Chapter 3, PART THREE of ISC Rules for Materials and Welding.

2.3 Welding Capability Tests

2.3.1 The intelligent welding equipment for shipbuilding can be categorized as: collaborative welding robots, robot welding workstations, pipe welding machines, trackless crawling robots and assembly robot welding production lines, etc.

2.3.2 According to the different types of welding equipment, the applicant is to draft the welding capability test program for the equipment, and the tests are to be carried out upon agreement of ISC.

2.3.3 The welding capability tests are to be reasonably planned based on the functional characteristics of the equipment. The test program generally includes the following contents:

(1) Model of the intelligent welding equipment;

(2) Specific form of the test (refer to 2.3.5 of this Chapter);

(3) Specific implementation of the intelligent level that the equipment can achieve in 2.1.3 (for items marked as "no requirement", if the equipment can also achieve them, it can also apply for verification);

(4) Material information of the test specimen;

(5) Form and size of the test specimen;

(6) Groove form of the test specimen;

(7) Welding procedure specifications or pre-weld procedure specifications;

(8) Appearance of welded joints and NDT plan;

(9) Other tests;

(10) Qualification requirements for the test.

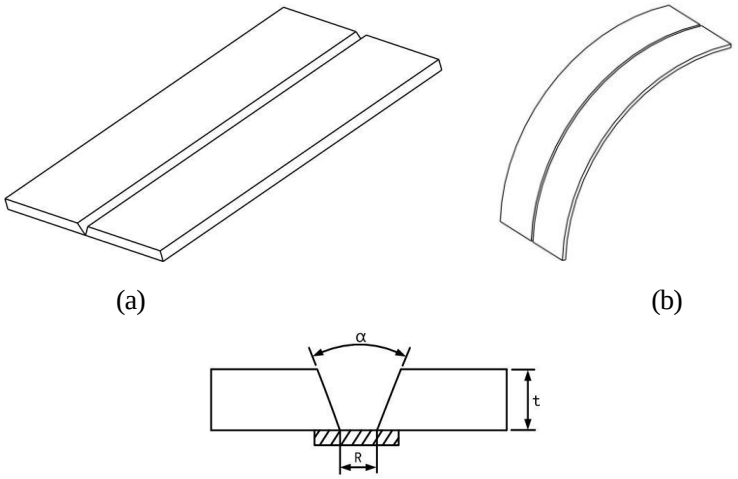
2.3.4 If the tests meet the requirements of the welding procedure approval tests in Section 2.2 of this Chapter, it can be carried out simultaneously with the welding procedure approval tests on this basis.

2.3.5 The form of the welding capability tests are to be agreed upon by the applicant and ISC and may take the following forms.

(1) Plate butt welding test

As shown in Figure 2.3.5(1), the plate butt test generally uses a single-sided groove, with a steel or ceramic backing. The plate thickness t is generally 10 to 20 mm. Normally, one or more welding positions such as flat welding, horizontal welding, vertical welding, and overhead welding are carried out. The test specimen may be a curved plate, and other test specimen forms may be used

upon agreement of ISC. After welding, visual examination, surface and internal NDT are to be carried out, and the test results are to meet the requirements of ISO 5817 Level B or other equivalent standards.



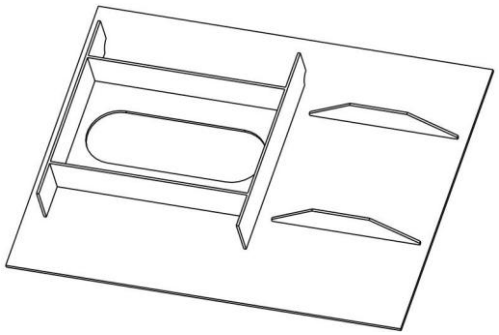
(a) (b)

(c)

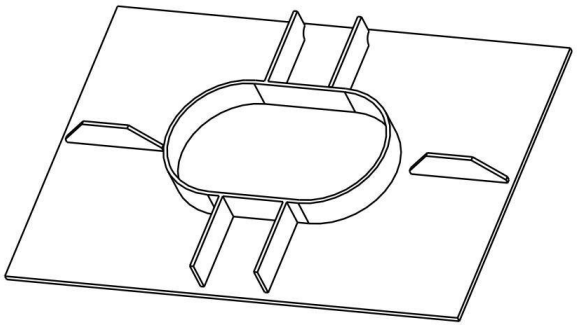
Figure 2.3.5(1) Forms of Butt Welding Specimens

(2) Primary assembling fillet welding test

The primary assembling fillet welding test specimen may be in the forms shown in Figure 2.3.5(2), and the actual size of the test specimen is to be agreed upon by the applicant and ISC. Generally, flat fillet welding and/or vertical fillet welding is be carried out. If conditions permit, end fillet welding is to conducted and over-welding holes are to be set. After welding, visual examination and surface NDT are to be carried out, and the test results are to meet the requirements of ISO 5817 Level B or other equivalent standards.



(a)



(b)

Figure 2.3.5(2) Forms of Small Assembly Fillet Welding Specimens

(3) Middle assembling fillet welding test

The middle assembling fillet welding test specimen may be in the forms shown in Figure 2.3.5(3), and the actual size of the test specimen is to be agreed upon by the applicant and ISC. Generally, flat fillet welding and vertical fillet welding are be carried out. If capability allows, overhead fillet welding may also be performed, and different welding procedure parameters can be retrieved and used. After welding, visual examination and surface NDT are to be carried out, and the test results are to meet the requirements of ISO 5817 Level B or other equivalent standards.

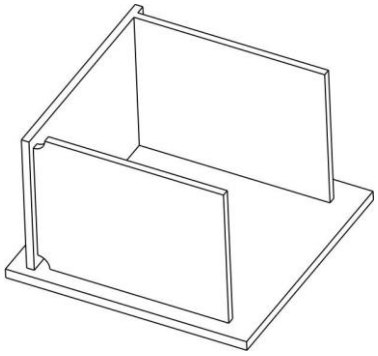
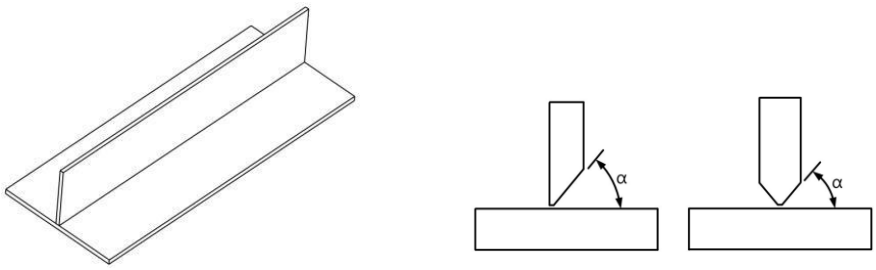


Figure 2.3.5(3) Forms of Medium Assembly Fillet Welding Specimens

(4) Partial penetration and full penetration T-joint tests

Partial penetration and full penetration T-joints are to be completed with full weld seams in accordance with the welding procedure specifications. The form of the test specimens may be as shown in Figure 2.3.5(4), and the sizes and welding positions of the specimens are to be agreed upon by the applicant and ISC. After welding, visual examination, surface and internal NDT are to be carried out, and the test results are to meet the requirements of ISO 5817 Level B or other equivalent standards.



(a) (b)

Figure 2.3.5(4) Forms of Partial Penetration and Full Penetration T-joint Specimens

(5) Pipe welding test

Pipe welding test specimens are divided into pipe butt welding, pipe-to-pipe fillet welding and pipe-to-plate fillet welding. Welding of a single complete joint is carried out using actual pipes, sleeves and flanges. The actual sizes and forms of the test specimens are to be agreed upon by the applicant and ISC. The welding position is to be agreed upon by the applicant and ISC based on the actual condition. After welding, visual examination, surface and internal NDT are to be carried out for the butt welding, and visual examination and surface NDT are to be carried out for the fillet welding. The test results are to meet the requirements of ISO 5817 Level B or other equivalent standards.

(6) Intelligent capability tests

The intelligent capability tests can be carried out simultaneously with the tests in (1) to (5) above.

① Weld seam tracking

General weld seam tracking is normally not to be verified individually, but may be verified in the tests in (1) to (5). In the case of larger curved weld seams, individual verification is required. The forms of verification test specimen can be as shown in Figure 2.3.5(6)-1, and the actual sizes and forms of the test specimen are to be agreed upon by the applicant and ISC.

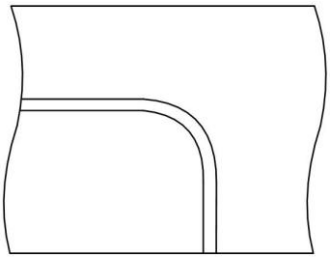
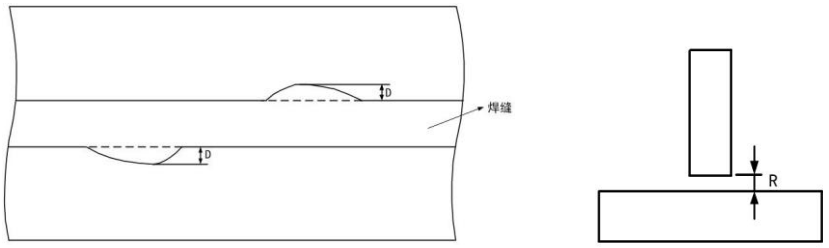


Figure 2.3.5(6)-1 Weld Seam Tracking Specimen

② Parameter self-adaptation

Intelligent welding equipment has the ability to dynamically optimize welding parameters in the welding process, automatically analyze and invoke procedure parameters to adapt to the changes in actual bevels and root gaps. The forms of the verification test specimen can be as shown in Figure

2.3.5(6)-2. The actual sizes and forms of the test specimens are to be agreed upon by the applicant and ISC.



(a) (b)

Figure 2.3.5(6)-2 Welding Parameter Self-adaptation Specimen

③ Intelligent modeling

Intelligent welding equipment can achieve parallel and integrated modeling through single or multiple technical paths such as drawing modeling, parameter modeling, or visual reverse modeling. The specific test methods are to be agreed upon by the applicant and ISC.

④ Trajectory planning

During the welding process, intelligent welding equipment can identify welding paths, plan welding sequences and weld bead arrangements, and coordinate multiple robots when necessary. The specific test methods are to be agreed upon by the applicant and ISC.

2.4 Approval of Welding Procedure Database

2.4.1 When intelligent welding equipment manufacturers, shipyards or marine product manufacturers carry out the welding procedure approval for a given scenario, the welding procedure database approval may be applied for, and the data volume is to meet the manufacturing requirements of the scenario.

2.4.2 The database is to have the function of storing procedure parameters, generally including information on base materials and welding consumables, type of joints, weld toe sizes, welding methods, welding positions, welding currents, welding voltages, welding speeds, gas compositions and flow rates, arc swing widths and frequencies, etc.

2.4.3 Intelligent welding equipment can store the welding procedure parameters of this database and can call and perform welding according to actual manufacturing needs.

2.4.4 Approval test is to be carried out for the welding procedure database approval. The specific approval methods are to be agreed upon by the applicant and ISC. The tests generally meet the following requirements:

(1) Tests cover the plate thickness or weld toe sizes of fillet welds required for manufacturing;

(2) Test methods may be carried out in accordance with 2.3 of this Chapter or agreed upon with ISC;

(3) Test parameters meet the approved welding procedure specifications.

2.5 Operational Verification

2.5.1 If the operational verification is required by applicant, it is generally applied for after the capability certification of the intelligent welding equipment has been obtained. If the capability certification has not been carried out for the equipment, relevant materials are to be submitted or tests are to be conducted to prove its capability. Operational verification usually involves the operation of the intelligent welding equipment in actual shipbuilding welding for a certain period of time to complete a verification cycle.

2.5.2 The main purpose of operational verification is to verify the operational reliability of the equipment. The following materials are to be submitted:

(1) Relevant proof materials of the actual use of the equipment;

(2) The qualification of the randomly inspected weld seams during the actual use of the equipment,

2.5.3 Operational verification is generally to meet the following requirements:

(1) The actual usage time of the equipment within one verification cycle is to be no less than 350 hours;

(2) The welds randomly inspected within one verification cycle are to cover the capability level of the equipment, with the random inspection ratio being no less than 5%, and the acceptance rate of the inspection is to be no less than 98%, meeting the requirements of ISO 5817 or other equivalent standards.

CHAPTER THREE INSPECTION OF APPLICATION OF INTELLIGENT WELDING EQUIPMENT

3.1 Inspection of Application of Intelligent Welding Equipment

3.1.1 For the inspection requirements for application of intelligent welding equipment, see Table 3.1.1. In case that the equipment has not been certified for level, ISC is to determine the level according to the actual equipment.

Inspection of Application of Intelligent Welding Equipment **Table 3.1.1**

Item / Level	Requirements for procedure approval and capability tests	Requirements for welding operators
WL0	Welding procedure approval	Holdingwelding operator qualification certificate
WL1	Welding procedure approval	Holding welding operator qualification certificate
WL2	Welding procedure approval + welding capability tests	Holding training certificate
WL3	Welding procedure approval + welding capability tests	Holding training certificate
WL4	Welding procedure approval + welding capability tests	Holding training certificate
WL5	Welding procedure approval + welding capability tests	Not required for operators

3.2 Requirements of Welding Procedure Approval and Welding Capability Tests for Intelligent Welding Equipment

3.2.1 When intelligent welding equipment is used for shipbuilding on-site, it is to be generally inspected in accordance with Table 3.1.1.

3.2.2 When intelligent welding equipment is used by shipyards or marine product manufacturers for fabrication, procedure approval is to be carried out in accordance with the requirements for automatic welding procedure tests in Chapter 3, PART THREE of ISC Rules for Materials and Welding. The scope of application of the approved welding procedure is to be determined based on the equipment conditions, but is not to exceed the application stipulated in 3.1.4, Chapter 3, PART THREE of ISC Rules for Materials and Welding.

3.2.3 The intelligent welding equipment manufacturers are to write the procedure parameters in the welding procedure specifications approved by the shipyard or marine product manufacturers into the welding procedure database of the welding equipment and provide the relevant parameters of the

database to ISC for inspection. The procedure parameters of the equipment are applicable to workshops of the shipyard or marine product manufacturers with the identical technical and quality management conditions.

3.2.4 Welding capability tests are to be carried out by use of typical materials and parameters within the scope of the welding procedure specifications, in accordance with the requirements of 2.3, Chapter 2 of the Guidelines. If the relevant welding equipment has obtained the intelligent welding equipment capability certification certificate, it is unnecessary to carry out the tests.

3.2.5 If a shipyard or marine product manufacturer obtains the relevant certificates as described in 2.1.8 of Chapter 2 of the Guidelines, the certificates are only applicable to the shipyard or marine product manufacturer that has obtained them.

3.3 Requirements of Welding Operators

3.3.1 Based on the intelligent level of the intelligent welding equipment, operators of WL1 equipment is to hold a welding operator qualification certificate accepted by ISC.

3.3.2 Operators of WL1 intelligent welding equipment are generally to obtain the welding operator qualification certificate in accordance with the relevant requirements of Section 3, Chapter 3 of ISC Guidelines for Inspection of Hull Welds.

3.3.3 Operators of WL2 to WL4 intelligent welding equipment are to undergo certain training and obtain training certificates accepted by ISC before actual operation. Corresponding training certificates are to be obtained for different equipment manufacturers, different equipment models, and different equipment levels. The training is to be conducted by the relevant intelligent welding equipment manufacturers or shipyards/marine product manufacturers and corresponding training certificates are to be issued.

3.4 Post-weld Inspection

3.4.1 Key parameters such as welding current, voltage, welding speed, etc., are to be collected through sensors of the intelligent welding equipment. The consistency of the collected data in the welding process with the actual measurements is to be verified. The welding parameters collected by the verified collection system may be recorded in the welding process patrol inspection record.

3.4.2 For weld seams made by WL3 or higher intelligent welding equipment, advanced ultrasonic testing such as phased array ultrasonic testing may be used to replace radiographic testing in some areas after verification. The specific verification methods and areas are to be agreed upon by the applicant and ISC.

3.4.3 For weld seams made by WL1 or higher intelligent welding equipment, if visual examination has been carried out carefully by the surveyor, the tightness test may be reduced, but it is to be in combination with NDT and verified. The specific reduction proportion and range of the tightness test are to to be specially considered by ISC.

3.4.4 If the equipment has the following welding quality analysis and diagnosis capabilities, the inspection range may be increased for areas that may have defects and reduced for areas that may have no defects as appropriate. The specific areas are to be agreed upon by the applicant and ISC.

Welding quality analysis and diagnosis are to be compared and verified with traditional NDT. The specific verification methods are to be agreed upon by the applicant and ISC.

(1) The intelligent welding equipment is capable of identifying defects through intelligent training with the data collected in 3.4.1 and parameters including but not limited to the molten pool, dynamic posture of the welding torch, on-site environment, etc.;

(2) The intelligent welding equipment analyzes and diagnoses the collected parameters, including online monitoring and post-data analysis, and can predict welding defects by use of the above-mentioned capabilities.