

**RULES
FOR THE CLASSIFICATION OF
SHIPS**

*Part 25 – METALLIC MATERIALS
January 2025*

*Amendments No. 1
July 2025*

CROATIAN REGISTER OF SHIPPING

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By the decision of the General Committee of Croatian Register of Shipping,

Amendments No. 1 to the
RULES FOR THE CLASSIFICATION OF SHIPS
Part 25 – METALLIC MATERIALS

have been adopted on 27th June 2025 and shall enter into force on 1st July 2025

GENERAL TERMS AND CONDITIONS

(March 2022)

Article 1 GENERAL

1.1 CROATIAN REGISTER OF SHIPPING (hereinafter: the *Register*) shall at all times remain an independent contractor and neither the *Register* nor any of its officers, surveyors, auditors, inspectors, agents, appointers, officers or managers shall act as an employee, servant or agent of any other party in the performance of the Services rendered by the *Register*.

1.2 The *Register* acts as a service provider. The Services provided by the *Register* cannot be construed as a commitment by the *Register* to achieve any result or as a warranty.

1.3 The provision of Services is subject to these General Terms and Conditions. No other terms and conditions shall apply, either expressly or by implication, unless expressly agreed in writing between the Parties.

1.4 These General Terms and Conditions shall be incorporated into, or referred to in any Contract and shall prevail over and exclude any other terms and conditions that the Client may wish to impose.

Any amendments to and/or deviations from these General Terms and Conditions, as well as any additional terms and conditions of the Client, shall be binding or valid only if set forth in writing and duly signed by the authorised representatives of both Parties.

1.5 The invalidity of one or more provisions of these General Terms and Conditions shall not affect the remaining provisions.

1.6 The Client acknowledges that the latest version of these General terms and Conditions and the latest version of applicable Rules apply to the Services provided by the *Register*.

1.7 Definitions in these General Terms and Conditions take precedence over other definitions that may appear in other documents issued by the *Register*.

1.8 The Client should at all times be aware of the provisions of these General Terms and Conditions, as they may be further amended, with their latest up to date version available on the web site of the *Register*.

Article 2 DEFINITIONS

2.1 **Certificate** means either a class certificate or statutory certificate, statement, attestation, statement of compliance, and a report following the Services provided by the *Register*.

2.2 **Certification** means the activity of certification in application of international and national standards and international industry practice provided by the *Register*.

Certification is an appraisal given by the *Register* to the Client and cannot be construed as an implied or express warranty of safety, fitness for purpose, seaworthiness of the vessel or its value for sale, insurance or chartering.

The purpose of Certification is to provide classification and statutory services and assistance to the maritime industry, Flag State Administrations, and regulatory authorities relating to maritime safety and pollution prevention.

2.3 **Classification** includes all activities and Services provided by the *Register* in accordance with the Rules. Classification may or may not be accompanied by the issuance of a Certificate of class with reference to the Rules.

Certificate of class is valid only if issued by the *Register*.

However, Certificate of class should not be construed as a guarantee of the safety, fitness for purpose or seaworthiness of the vessel. It is merely an attestation that the vessel complies with the Rules developed and published by the *Register*.

In addition, the *Register* is not a guarantee of the safety of life or property at sea or the seaworthiness of a vessel because, although the classification of a vessel is based on the assumption that the vessel will be properly loaded, operated, and maintained by competent and qualified personnel, the *Register* has no control over how a vessel is operated and maintained between the periodic surveys it conducts.

2.4 **Statutory certification** means certification made by the *Register* on behalf of the Flag State Administrations when and to the extent that the *Register* has been authorised to do so by the respective Flag State.

Statutory certification and services include the assessment of vessels registered by the Flag State and/or ship management companies to determine whether such ships/companies comply with the applicable requirements of international conventions, codes and national legislation, and the issuance of, or assistance in the issuance of, the appropriate certificates and documents.

Statutory certification includes, but is not limited to, certification, survey, and issuance of statutory certificates on behalf of the Flag State.

In cases where the *Register* acts on behalf of Flag State Administrations, the *Register* shall follow guidance issued by IMO (Resolutions, Circulars, etc.) or by IACS through Unified Interpretations (UI), unless otherwise directed by the Flag State.

2.5 **Client** means the shipowner, company, shipyard and/or party requesting Services or taking ownership of a classed vessel. In cases where shipowners have authorized another party to operate the vessel on their behalf, that party shall be considered as the company.

In addition to the above the Client means the person and/or entity that has requested Services from the *Register* and that has entered into a Contract or an agreement for Services with the *Register*.

2.6 **Parties** means the *Register* and Client together.

2.7 **Party** means the *Register* or the Client.

2.8 **Contract** means the contract in the form of a written agreement between the Client and the *Register* requesting Services, including these General Terms and Conditions and the Rules.

The provisions related to the Contract in these General Terms and Conditions shall apply even if there is no written agreement between the Client and the *Register*.

The Client may request the *Register* in writing to make a change to the contracted Services. However, the *Register* shall not be obligated to accept or execute any such change until a written agreement has been signed with the Client regarding the compensation and the possible impact of the change on the schedule as an addendum to the originally contracted Services.

2.9 **Services** shall mean the services specified in 2.2, 2.3 and 2.4, but also other services related to certification, classification and statutory certification, such as, but not limited to: ISM Code certification, ISPS Code, MLC 2006 certification, fuel oil consumption reporting, IHM certification, approval of manufacturers and service providers, certification of materials and products, training activities, conformity assessment, and any other relevant activities such as third party inspections, testing, shore and shipboard trials.

The Services provided by the *Register* are performed on a random basis and in no case include a full inspection of all items.

The *Register* shall provide the Services in accordance with related Contract(s), the provisions of these General Terms and Conditions, Rules, the international and national standards, the international conventions, the EU Regulations, the Flag State requirements and the industry practices applicable to the particular Service and always assuming that the Client is aware of these standards and the industry practices.

When providing Services, the *Register* does not guarantee the accuracy of the information or advice provided.

In providing Services, the *Register* does not assess compliance with standards other than the Rules, international and national standards, international conventions, EU regulations, Flag State requirements and industry practice, to the extent agreed in writing or specified in the Contract.

2.10 The *Register* means the Croatian Register of Shipping, an entity organized and existing under Croatian law, which, according to the Law on the Croatian Register of Shipping (Official Gazette No. 1996/81, 2013/76 and 2020/62) and the Charter of the *Register*, is an independent, not-for-profit, but public welfare oriented, public foundation that performs tasks:

- classification of sea-going ships,
- statutory certification of sea-going ships on behalf of the Flag State Administrations,
- classification of inland navigation vessels,
- statutory certification of inland navigation vessels,
- statutory certification of recreational crafts,
- certification of materials and products,
- conformity assessment of recreational crafts,
- conformity assessment of marine equipment,
- conformity assessment of pressure vessels,
- certification/registration of quality management systems.

2.11 **Vessel** means a ship, vessel, unit or offshore structure of any kind, whether or not connected to the shore or sea/river bed, located at sea or in inland waters and intended for transportation or special operations on the water, as decided by the *Register*.

2.12 **Rules** means the Rules for the classification, guidelines, instructions, or other documented evidence of the *Register* related to the Services provided.

The competent interpretation of the requirements specified in the Rules or other regulations published by the *Register* shall be the exclusive responsibility of the *Register's* Head Office, notwithstanding any possible different interpretations by other parties.

In cases where the Rules do not contain detailed requirements, the specific approval by the *Register* shall be based on the principles of the Rules and shall ensure a safety standard equivalent to that of the Rules.

Article 3 RESPONSIBILITIES

3.1 It is the Client's responsibility to ensure that all surveys required for vessel's class maintenance are conducted in a timely manner and in accordance with the Rules.

3.2 The *Register* may suspend or withdraw the vessel's existing Certificate of class in the event of serious deficiencies and replace it with a new Certificate of class with a shortened period of validity during which the deficiencies are to be rectified.

In addition, the *Register* shall suspend or withdraw a vessel's Certificate of class if the deficiencies are of such a magnitude as to endanger the class of the vessel, its safety and integrity, the safety of the crew, passengers, or the marine environment, and shall require that the vessel is to be inspected at the first port of call where the necessary repairs are to be carried out.

3.3 The Client should inform the *Register*:

- (i) in the event of a change in the intended use of a vessel, a conversion and alteration of the hull, machinery installations and other equipment affecting the Class of the vessel assigned by the *Register*. Conversions and alterations must be made under the supervision of the *Register* and must comply with the requirements of the Rules and/or additional requirements of the *Register*,
- (ii) in cases where the vessel has been damaged to such an extent that the Class of the vessel is likely to be affected and the safety and integrity of the vessel is likely to be compromised. In such cases, the vessel must be surveyed at the first port of call or as further directed by the *Register*. The survey shall be to the extent deemed necessary by the *Register*, by taking into account the extent of the damage.
- (iii) in cases where class-related deficiencies and/or defects are found as a result of a Flag State inspection or Port State Control. Should the Client fail to notify the *Register* of the detention of the vessel by Port State Authorities due to class related deficiencies, the *Register* reserves the right to suspend or withdraw the Certificate of class.

3.4 The *Register* shall have full control over Certificates issued and may suspend or withdraw a Certificate at any time in its sole discretion if the Client fails to comply with the following requirements set forth in the *Rules for the Classification of Ships, Part 1 - General Requirements, Chapter 1 - General Information*, as applicable:

- (i) para. 5.3 - *Maintenance of the validity of Certificate of Class*,
- (ii) para. 5.4 - *Period of Validity*,
- (iii) para. 5.5 - *Extension of the Period of Validity*,
- (iv) para. 5.6 - *Suspension and Reinstatement of Class in the Case of Overdue Surveys*, and
- (v) para. 5.7 - *Withdrawal of Class*.

3.5 The *Register* may suspend or withdraw a Certificate at any time in its sole discretion if the Client fails to comply with the following requirements set forth in the *Rules for the Classification of Inland Navigation Vessels, Part 1 - Classification and Surveys, Chapter I - Principles of Classification*, as applicable:

- (i) para. 2.8 - *Maintenance of the Validity of the Certificate of Class*,
- (ii) para. 2.9 - *Extension of validity of the Certificate of Class*, and following requirements set forth in the *Rules for the Classification of Inland Navigation Vessels, Part 1 - Classification and Surveys, Chapter II - Classification*, as applicable:
- (iii) para. 2.1 - *Suspension of Class*,
- (iv) para. 2.2 - *Withdrawal of Class*.

3.6 In addition to clauses 3.2, 3.4 and 3.5 of this Article, the *Register* reserves the right to terminate the Services and related Contract in the event of a breach of the provisions of these General Terms and Conditions.

3.7 If the Client fails to provide the *Register* with the required access or information at the agreed times or fails to prepare for the Service in a timely manner, the *Register* may suspend the provision of the Service until it receives the Client's instructions for access and/or the required information.

The *Register* shall not be liable for the consequences of such suspension, and the Client shall be responsible for the *Register's* additional fees and other unnecessary costs and expenses incurred by the *Register*.

3.8 The Client is obliged to perform timely payments of the invoices for provided Services. However, the *Register* may retain or withhold any Service or Certificate to the Client in the case of outstanding payments, whether mutually related or not, arising out of the entire business relationship with the Client.

Article 4

HEALTH, SAFETY AND ENVIRONMENT

4.1 Both the *Register* and the Client shall apply reasonable standards to promote safety, health, and environmental protection and to provide a safe working environment for their personnel.

4.2 The Client shall provide the *Register* with all access and information necessary for the safe and efficient performance of the requested Services as required by the Rules.

4.3 During the survey, personnel of the *Register* should have secure access to all work that directly or indirectly affects the Service.

4.4 The *Register* has the right to refuse to conduct an activity or visit an area or site if the *Register* in its sole discretion, believes that relevant risks are unacceptable or are not adequately addressed, contained, or otherwise mitigated.

Such a decision shall suspend the obligations of both Parties under the Contract without incurring any liability or penalty until the Parties agree on how to proceed.

Article 5

THIRD PARTIES AND SUBCONTRACTORS

5.1 Each specific Contract, including any Certificates issued, relates specifically to the Client, and no rights, obligations, interests, claims, benefits or Certificates issued shall extend to any third party without the prior written consent of the *Register*.

5.2 The Client shall not be entitled to grant any right to use the Certificates to any third party without the prior written consent of the *Register*.

5.3 The Client shall not without *Register's* consent, cede, assign, transfer, subcontract or deal in any manner with all or any of its rights or obligations under any Service and related Contract.

5.4 With regard to third party rights to access information and Certificates under confidentiality clause reference is to be made to Article 9.

Article 6

TAXES

6.1 Each Party shall be responsible for and shall bear all taxes, duties or similar governmental charges levied or imposed on any activity of that Party.

6.2 Prices, fees, rates, or remuneration are exclusive of any form of sales tax, value added tax, administrative fees and services tax and/or other similar taxes, including any surcharges. If any such indirect tax is or becomes applicable to the Services provided under the Contract, the Client shall be responsible for the payment of such indirect taxes.

Article 7

PAYMENT OF INVOICES

7.1 The provision of Services by the *Register*, whether complete or not, shall include payment of fees thirty (30) days after issuance of the invoice for the portion of the Services performed.

7.2 In the event that the Client fails to meet the requirements for payment in accordance with the instalments and terms of payment contained herein, the *Register* reserves the right to charge the Client with the interest rate in accordance with the applicable laws of the Republic of Croatia.

7.3 If the Client disputes an invoice or part of an invoice, the Client shall notify *Register* thereof in writing without undue delay. If no notification is received by the due date, Client shall be deemed to have accepted the invoice in full. If only part of an invoice is disputed, the undisputed amount must be paid by the due date.

Consequently, no disputes arising between the *Register* and the Client shall interfere with prompt payment of invoices by the Client. Any rights of lien or retention in favour of the Client or otherwise, are hereby excluded.

7.4 In the event of cancellation of all or part of the Services prior to their final completion, the Client shall pay all costs incurred by the *Register* on pro-rata basis for the portion of the Services provided to date. In such event, the *Register* will not claim the Client for loss of profit or reduced income. All reasonable costs directly attributable to the early termination and all amounts due to the *Register* at that time shall become immediately due and payable.

7.5 In the event of termination of the Service and related Contract, the *Register* shall be entitled to retain any payments, deposits or prepayments of fees made by the Client prior to the date of termination up to the amount to which the *Register* is entitled.

Article 8

TERMINATION

8.1 The Parties shall have the right to terminate the Services and the related Contract(s) by written notice to the other Party, and without prejudice to Article 7, in the following cases:

- (i) if the other Party commits a material breach of these General Terms and Conditions and/or the Contract and fails to rectify such breach in accordance with clause 8.4 of this Article,
- (ii) if the other Party becomes insolvent, is unable to pay its debts as they become due, or becomes subject to bankruptcy proceedings, administration, receivership, dissolution, liquidation, winding up or otherwise ceases to carry on its business; or
- (iii) for convenience, after giving the other Party thirty (30) days' prior written notice of termination.

8.2 The Classification issued for the relevant vessel and the Certificates previously issued shall remain valid until the effective date of termination or, in the event of such termination, immediately, subject to compliance with Article 3 and Article 7.

8.3 If, in the reasonable opinion of the *Register*, the Client breaches or is suspected of breaching Article 14 or Article 15, the *Register* shall have the right to terminate the Service and related Contract with immediate effect.

8.4 Notwithstanding the provisions of clause 8.1 of this Article, the Party intending to terminate Services for non-compliance or breach of the provisions of these General Terms and Conditions shall notify the other Party of the non-compliance or violation of the provisions of these General Terms and Conditions and set a reasonable deadline of 15 (fifteen) days for the other Party to remedy the breaches of the provisions of these General Terms and Conditions.

If the Party fails to remedy the breaches of the provisions of these General Terms and Conditions within the aforementioned period, the other Party shall have the right to terminate Services without further notice.

8.5 Termination of the Service and related Contract pursuant to the provisions of these General Terms and Conditions shall not give either Party the right to claim any additional compensation, indemnity or reimbursement from the other Party as a result of such termination, but such termination shall not affect any rights or remedies available to a Party at the time the termination becomes effective or any obligations or liabilities incurred by a Party.

Article 9 CONFIDENTIALITY

9.1 The Parties agree to keep confidential all facts, data, information, etc. related to the other Party's business that they have learned in the course of providing Services. Such information and data shall not be disclosed by the Parties to any third party and shall not be used or misused to the detriment of the other Party.

9.2 The *Register* will keep confidential any data, plans or other technical information received from the Client and will not disclose it to any third party outside the *Register*, unless authorised by the Client. This obligation shall continue to apply after termination of the Services. This obligation shall not apply to any data, plans or other technical information that was in the possession of the *Register* prior to being disclosed to the *Register* by or on behalf of the Client, or that becomes publicly available through no fault of the *Register*, or is otherwise provided to the *Register* by an independent source that is under no obligation of confidentiality to the *Register*.

9.3 Certificates issued by the *Register* to the Client as a result of the Services provided shall not be covered by the confidentiality Article.

Notwithstanding the foregoing, the Client shall be entitled to disclose any data to its affiliates involved in the transactions related to the Services or the Client's core activities.

9.4 Notwithstanding clause 9.1 and clause 9.2 of this Article, the *Register* shall have the right to disclose the Confidential Information to the following parties if required by regulations of:

- (i) authorised representatives of the Flag State Administration,
- (ii) authorised audit teams (i.e., accreditation body or EC auditors),
- (iii) the International Association of Classification Societies (IACS),
- (iv) a court of competent jurisdiction, government agency, or other relevant public authority, in accordance with applicable law, court order, or other public regulation.

9.5 The Client acknowledges that the *Register* is required to provide access to information to the EU Commission or any person acting on its behalf in accordance with applicable EU requirements and that the Client shall give the EU Commission with unrestricted access to the vessels for the purpose of inspection.

9.6 The obligations in this Article shall survive the conclusion of the Service or the termination of related Contract and shall continue for as long as the relevant information remains confidential.

Article 10 INTELLECTUAL PROPERTY

10.1 Each Party shall be the sole owner of all rights to its Intellectual Property created before or after the effective date of these General Terms and Conditions, whether or not associated with any Contract between the Parties.

10.2 The Intellectual Property developed by the *Register* for the provision of the Services, including but not limited to drawings, calculations and reports, shall remain the exclusive property of the *Register*.

Article 11 PROFESSIONAL ETHICS

11.1 Each of the Parties warrants that, with respect to the matters contemplated herein, neither it nor its affiliates has made or will make, directly or indirectly, any offer, payment, gift or authorization of money to any government official or employee, political party, public official or candidate for the benefit or advantage thereof.

11.2 In providing the Services, the *Register* shall strictly adhere to the requirements of its Code of Ethics relating to business activities.

Article 12 FORCE MAJEURE

12.1 For the purposes of these General Terms and Conditions, the term "Force Majeure" includes any event that directly or indirectly prevents the Parties from fulfilling their obligations due to events beyond their control, such as: strikes, wars, riots, piracy, civil commotion, malicious damage, pandemic, compliance with laws or government orders, rules, regulations or directives, sanctions and embargoes, accidents, defects of plants or machinery, seizures, fires, floods, storms and the like.

12.2 If either Party is prevented or delayed from performing its obligations by Force Majeure, such Party shall promptly notify the other Party in writing of the circumstances of the Force Majeure and its influence and, after such notification, shall not be liable for performance of any obligations prevented by the influence of the Force Majeure during its duration. Upon termination of the influence of the Force Majeure, the same Party should proceed with the planned activities in order to fulfil its obligations.

12.3 If one of the Parties is prevented by Force Majeure in its activities and fulfilment of its obligations and this event lasts continuously for three (3) months, the other Party shall be entitled to terminate the Service and related Contract without liability.

12.4 Neither of the Parties shall be liable for non-compliance with these General Terms and Conditions due to Force Majeure. If one of the Parties is prevented from fulfilling its obligations under these General Terms and Conditions due to Force Majeure, it shall immediately notify the other Party in writing within a reasonable period of time, stating the reasons for the Force Majeure and providing relevant evidence, if any.

Article 13 INDEMNIFICATIONS

13.1 Each Party shall indemnify the other Party against all claims arising out of the performance of the Services in respect of bodily injury, illness or death of any of its employees or other representatives and in respect of loss of or damage to the Party's property.

This provision shall apply whether or not the damage is caused or contributed to by the negligence of the other Party. Both Parties are obliged to take out separate insurances for these liabilities.

13.2 The Client shall indemnify the *Register* from and against all claims arising from the Client's violation of the provisions of these General Terms and Conditions and from the misuse of the Certificates issued by the *Register*.

13.3 The Client shall indemnify the *Register* against any financial responsibility or amounts arising from non-payment, late payment or payment of withholding taxes to the non-relevant tax authority or any other relevant governmental body.

13.4 Each Party shall notify the other Party without undue delay as soon as it becomes aware of any incident that could give rise to a claim against the other Party in respect of the Service provided and related Contract.

Article 14 ANTI-CORRUPTION

14.1 Each Party agrees that in performing its obligations under any Service, it will ensure that its affiliates, employees and/or agents, subsidiaries, subcontractors, consultants, and any other persons providing Services will:

- (i) comply with all applicable anti-bribery and anti-corruption laws (collectively, Anti-Bribery Laws) and, in particular, do not, directly or indirectly, offer, promise, grant, authorise the payment of, or confer any financial or other benefit on any public or government official:
 - to a public or governmental official to obtain or retain business with the intent to influence such official in his or her capacity as an official, if such official is not permitted or required by written law to be influenced by the offer, promise or gift; or
 - to another person with the intent to induce or reward the improper performance of a function or activity or for any other illegal purpose,
- (ii) maintain adequate systems and procedures designed to prevent activities, practises, or conduct in connection with services that would constitute an offence under an anticorruption law; and
- (iii) take reasonable steps to prevent similar acts by customers, contractors, subcontractors, agents and other third parties, persons under its control or influence.

14.2 Any failure by a Party to comply with or ensure compliance with its obligations under this Article shall, notwithstanding anything to the contrary in these General Terms and Conditions, be deemed a breach of these General Terms and Conditions which shall entitle the other Party to suspend and/or terminate the Services by notice in writing with immediate effect without further liability to the other Party except for any liability which may have arisen prior to the date of termination or suspension (as the case may be).

14.3 If a Party elects to suspend the provision of Services under these General Terms and Conditions pursuant to this Article, it shall have the sole and absolute discretion to determine:

- (i) when it will resume performance (if at all); and
- (ii) extend the period for performance of its obligations under the Services in its sole discretion.

Article 15 SANCTIONS

15.1 Each Party shall conduct all activities in compliance with all laws, statutes, rules, economic and trade sanctions (including, but not limited to, U.S. sanctions and EU sanctions) and regulations applicable to such Party, including, but not limited to: child labour, forced labour, collective bargaining, discrimination, abuse, working hours and minimum wages, anti-bribery, anti-corruption, copyright and trademark protection, personal data protection.

15.2 Each Party hereby represents and warrants that it is not or will not be subject to any economic or trade sanctions ("Sanctions") imposed by the United States of America, the European Union, the United Kingdom, any EU Member State, or the United Nations with respect to any country and/or by any sanction giver with respect to any company/individual.

15.3 Each Party represents and warrants that it will strictly comply with all Sanctions.

15.4 Nothing in these General Terms and Conditions shall be construed as causing or obligating either Party to act or refrain from acting in a manner inconsistent with, punishable by, or prohibited by any Sanctions.

15.5 Neither Party shall be obligated to perform any obligation arising under these Terms and Conditions (including, without limitation, the obligation to):

- (i) perform, deliver, accept, sell, purchase, pay or receive any funds to, from or through any person or entity; or
- (ii) engage in any other action whatsoever, if doing so violates or is inconsistent with sanctions and/or recommendations of international (intergovernmental) organisations to combat the financing of terrorism and other criminal activities and/or money laundering or exposes such Party to investigation or penalties.

15.6 In the event that a Party breaches any Sanctions or the Party's Business and/or Transactions arising out of or in connection with these General Terms and Conditions breach any Sanctions or otherwise violate the recommendations of one or more international (intergovernmental) organisations for combating the financing of terrorism and other criminal activities and/or money laundering, the other Party shall be entitled to terminate these General Terms and Conditions by written notice with immediate effect without incurring any liability to the other Party, except for liabilities (if any) incurred prior to the date of termination.

Article 16 LIABILITY

16.1 The *Register* is not, and cannot be considered as, an underwriter, consulting engineer, naval architect, shipbuilder, shipowner, or ship management company, nor can it assume the obligations and responsibilities associated with such functions, although the *Register's* experience may enable it to respond to inquiries about matters not covered by its Rules, policies, instructions, or other documented evidence.

16.2 The practices and procedures of the *Register* shall be selected by the *Register* in its sole and absolute discretion based on its experience and knowledge and in accordance with generally accepted professional standards in the relevant field of classification societies.

16.3 Nothing herein contained shall release any designer, naval architect or engineer, shipbuilder or manufacturer, shipyard, vendor, supplier, contractor or subcontractor, repairer or owner, from any information, report, certificate or similar document issued in connection with the provision of Services by the *Register*, operator, manager or other person or entity from any express or implied warranty or other contractual obligation or responsibility, or from any negligent act, error or omission of any kind whatsoever, nor shall they create any right, claim or benefit for any third party.

16.4 The *Register* shall exercise due care in the selection or appointment of its surveyors and all other employees whose presence and work is necessary for the provision of the Services.

16.5 If any person or entity using the Services of the *Register* suffers any loss, damage or expense that is or is shown to have been caused by a negligent act, omission or error of the *Register's* officers, surveyors, auditors, inspectors, agents, appointers, officers or managers, or those purporting to act in the name of and on behalf of the *Register*, or a negligent inaccuracy, advice, report or evidence given by or in the name of or/and on behalf of the *Register*, then the liability of the *Register* is limited in respect of any direct or indirect claim shall be limited to an amount not exceeding five times the fee charged or to be charged by the *Register* for the relevant Service.

16.6 Any liability for consequential damages is expressly excluded.

For purposes of this clause, consequential damages include, without limitation:

- (i) indirect or consequential damages,

- (ii) loss and/or delay of production, loss of products, loss of use, loss of bargain, loss of revenue, loss of profit or anticipated profit, loss of business and business interruption, in each case directly or indirectly.

16.7 The Parties are not entitled to assign the performance of obligations under these General Terms and Conditions or parts thereof to third parties without the prior written consent of the other Party.

16.8 If during the term of the Contract, there is a transfer of function due to change of status (merger, acquisition, division, etc.), all obligations and rights under these General Terms and Conditions and associated Contract will be transferred to the legal successor of the Party concerned.

Article 17 GOVERNING LAW AND RESOLVING OF DISPUTES

17.1 These General Terms and Conditions and any dispute or claim between the Parties arising from or in connection with it, or the Services provided hereunder, will be governed and interpreted in accordance with the English law.

17.2 The Parties shall use their reasonable efforts to resolve any claim or dispute arising in relation to rendered Service by negotiations within a reasonable time.

17.3 Should the Parties fail to resolve any claim or dispute by negotiations, the dispute shall be exclusively subject to the jurisdiction of the Permanent Arbitration Court with the Croatian Chamber of Economy in Zagreb, Republic of Croatia.

17.4 The Parties agree to keep the any arbitration proceedings confidential.

17.5 Notwithstanding the above, any claim not presented within three (3) months of the completion of the particular Services, or within three (3) months of from the date when the events which are relied on were first discovered by the Client, shall be deemed waived and absolutely time barred.

17.6 Any objections against the line adopted by any of the *Register's* servants in fulfilling their duties or against the conclusions reached are to be raised to the *Register* by the Party as soon as possible.

If the Party is not satisfied with the final conclusions and interpretations by the *Register* the arbitration lays upon the Commission for appeal for Classification and Statutory certification of ships, which is to be formed according to the Regulation 39 of the Charter of the *Register*.

INTRODUCTORY NOTES

These amendments shall be read together with the requirements in the Rules for the classification of ships, Part 25 – Metallic materials, edition January 2025.

Table 1 contains review of amendments, where items changed or added in relating to previous edition are given, with short description of each modification or addition. All major changes throughout the text are shaded.

This Part of the Rules include the requirements of the following international Organisations:

International Association of Classification Societies (IACS)

Unified Requirements (UR): W2 (Rev.3, Sep 2021), W7 (Rev.4, Feb 2022), W8 (Rev.4, Mar 2024), W9 (Rev.2, 2004), W10 (Rev.2, 2004), W11 (Rev.9, 2017), W13 (Rev.7, Sep 2021), W14 (Rev.3, Sep 2021), W16 (Rev.3, 2016), W18 (Rev.6, Sep 2021), W24 (Rev.5, Sep 2023), W24 (Rev.5, Corr.1 Dec 2024), W25 (Rev.6, Sep 2021), W27 (Rev.3, Sep 2023), W27 (Rev.3, Corr.1 Dec 2024), W29 (2005), W30 (2013), W31 (Rev.3, Mar 2023), S33 (Rev.3, Feb 2020)

Recommendations (Rec.): Rec. 139 (2015), Rec. 69 (Rev.2, Oct 2020), Rec.68 (Rev.1, Apr 2021), Rec.169 (Sep 2021), **Rec.186 (Mar 2025)**

TABLE 1 – REVIEW OF AMENDMENTS

This review comprises amendments in relation to the Rules for the classification of ships, Part 25 – Metallic materials, edition January 2025.

<i>ITEM</i>	<i>DESCRIPTION OF THE AMENDMENTS</i>
SECTION 9	Completely new Section 9 - ADDITIVELY MANUFACTURED METALLIC PARTS FOR MARINE AND OFFSHORE APPLICATIONS is added, as a consequence of inclusion of IACS Rec. 186

9 ADDITIVELY MANUFACTURED METALLIC PARTS FOR MARINE AND OFFSHORE APPLICATIONS

■ New Section 9 ADDITIVELY MANUFACTURED METALLIC PARTS FOR MARINE AND OFFSHORE APPLICATIONS has been added and should be read as follows:

9.1 General

9.1.1 Scope

These requirements provide a framework for consistent quality for metallic additive manufacturing (AM) processes to be applied as an alternative to the traditional materials manufacturing process, such as rolling, casting, forging, welding in construction.

These requirements do not apply to hull structural members as defined in *Rules for the classification of ships, Part 2 - Hull*, Head 1.4 - Materials. The approval of any proposal to apply metallic additive manufacturing (AM) processes for hull structure members is subject to the *Register*.

For parts subject to classification, the manufacturer is to follow this recommendation. With the agreement of the *Register*, recognized international or national standards (refer to 9.1.7) may be accepted instead of sections of this recommendation for certified parts.

These requirements cover guidance, within the scope of classification or certification activities by the *Register*, for qualification tests, production control and documentation associated with the design, materials, manufacturing, inspection & testing for:

- a) Feedstock approval (Annex 1)
- b) Final material manufacturer approval (Annex 2)
- c) Part approval (Section 6)
- d) Repair procedure approval (Annex 3)

For metallic parts damaged in-service, an AM process could be selected for repair, which is similar to a welding repair for damaged metallic parts. The repair procedure or repair facility should be qualified and approved.

For the situations and projects involving reverse engineering, any such arrangements should be formally agreed to by the designer/original equipment manufacturers (OEMs), part manufacturer and end user.

Refer to 9.1.7 for international and national standards referenced in this document.

9.1.2 Metallic AM Process

These requirements cover the following metallic AM processes in accordance with ISO/ASTM 52900:2021, for marine and offshore applications, which can be further subcategorized as:

- a) Powder Bed Fusion (PBF) Process
 - PBF-LB: Powder Bed Fusion-Laser Beam
 - PBF-EB: Powder Bed Fusion-Electron Beam
- b) Directed Energy Deposition (DED) Process including Powder DED and Wire DED (also, named Wire Arc Additive Manufacturing, WAAM), which can be further subcategorized as:
 - DED-LB: Directed Energy Deposition-Laser Beam
 - DED-EB: Directed Energy Deposition-Electron Beam
 - DED-PA: Directed Energy Deposition-Plasma Arc
 - DED-GTA: Directed Energy Deposition-Gas Tungsten Arc
 - DED-GMA: Directed Energy Deposition-Gas Metal Arc
- c) Binder Jetting (BJT) or equivalent processes including post build sintering or an infiltration process to achieve the required material properties.

Notes:

Due to the process characteristics of BJT or equivalent processes, the final part, after de-binder and sintering/infiltration, may contain more and larger porosities than those parts built through the PBF and DED processes. Metallic parts through BJT or equivalent processes should be limited to non-cyclic loading applications until more successful service experiences are obtained.

9.1.3 Parts Categories

Part is technically defined as the combination of geometric requirements by CAD model or drawing (OEM/designer), material requirements by material specification (OEM/designer) and function requirements for the system (Purchaser). The part fabricated by the additive manufacturer should include the pre-build layout as specified in subsection 9.5.2 and a certificate of conformity which details the results of materials testing, inspection and non-destructive testing.

Parts are categorized into “class items” and “certified items”.

For class items, AM metallic parts should meet the existing requirements in accordance with the applicable Rules.

For certified items, AM metallic parts should meet applicable specifications in accordance with industry standards, designer or OEM requirements.

9.1.4 Criticality Levels

The criticality level of the AM metallic part can be determined from the service environment, a risk analysis and the potential consequence of part failure. For certified items, criticality levels should be determined by the part designer/manufacturer and agreed with the purchaser. Class items should be in accordance with the Rules, unless otherwise agreed by the part designer/manufacturer and the *Register*. Criticality levels are determined as follows:

- a) Non-critical application, refer to services for habitability in Section 4 of IACS UI SC 134 for machinery.
- b) Critical application, refer to primary essential services in Section 2 and secondary essential services in Section 3 of IACS UI SC 134 for machinery or structural members other than hull structural members.

9.1.5 Test Levels

For qualification/approval and quality control during production, test levels can be referred to the additive manufacturing level (AM Level):

- a) AM Level 1 for certified items for non-critical applications other than class items
- b) AM Level 2 for certified items for critical applications other than class items
- c) AM Level 3 for items subject to classification (hereinafter referred to as class items)

The agreed AM Level should be retained in the additive manufacturer's qualification/approval and production records.

9.1.6 Approval and Certification Process

The general process for approval and certification requirements is shown in Figure 9.1 as follows.

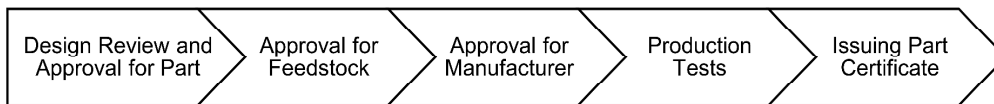


Figure 9.1
General Process for Approval and Certification

The details of requirements for AM feedstock, procedures, part and final material for approval are shown in Table 9.1 and listed as follows:

- a) Approval should be requested by the client, along with the submitted information and a detailed inspection and test plan (ITP) (refer to, Annex 1 for AM Feedstock Approval, Annex 2 for Additively Manufactured - Final Materials Approval, Section 9.6 for AM Part Qualification and Approval, and Annex 3 for AM Repair Facility Approval).
- b) The ITP should be agreed and should include Part Design, AM Procedure Specification (AMPS), Post Process, Non-destructive Testing (NDT), Materials Testing, Functional Testing, Part Qualification and Certification Plan, Repair Methodology Plan.
- c) The part design should be reviewed for geometry modification or a different material grade from the original design.
- d) The CAD model or drawing for AM Level 3 should be reviewed and approved in accordance with classification *Rules*. The CAD model or drawing for AM Level 2 and Level 1 could be reviewed and type approval could be issued in accordance with industry standards.
- e) The feedstock should be qualified according to international standards/specifications defined by the purchase specification for certified items, such as ISO 17296-2:2015, ISO/ASTM 52907:2019. The feedstock should be approved for class items by the *Register*. The approval of feedstock materials should be in accordance with Annex 1. The qualified/approved feedstock material should be linked to the feedstock supplier by a contractual agreement.
- f) For certified items, the purchaser should specify via a purchase order the requirements for manufacturer qualification. For this purpose, they can specify international standards/specifications, such as ISO/ASTM 52920:2023. For class items, the AM manufacturer should be approved by the *Register* in accordance with Annex 2. The range of approval should be determined by the *Register* and approved materials should be included in the manufacturer approval.
- g) If applicable, additive manufacturing repair procedures should be qualified according to international standards/specifications defined by purchase specification for certified items. Additive manufacturing repair procedures and facilities should be approved for class items by the *Register* in accordance with Annex 3.
- h) The *Register* should witness testing, review test results, complete the facility survey and issue an approval letter or certificate.
- i) During production, witness by the *Register* for final part acceptance is required prior to the issue of approval or certificates for class items in accordance with applicable Rules and in accordance with applicable industry standards for certified critical items. For non-critical items, witness by the *Register* is subject to agreement between the manufacturer and purchaser.

PART 25

AMENDMENTS No. 1

The initial survey should be conducted in accordance with the relevant steps in subsection 9.1.6 and Table 9.1. The approval tests should be witnessed by the attending surveyor. The annual survey should include a plan to demonstrate the essential parameters in Table 9.1 which should be followed during production.

Table 9.1
Approval and Certification Requirements

Qualification or Production Stages	Section or Subsection Number	Certified Items		Class Items
		AM Level 1	AM Level 2	AM Level 3
		Non-Critical	Critical	
		Requirements		
Part Design Review and Approval	9.3	MQ	MQ	CS
Powder Feedstock	9.4.1 and 9.4.2	MQ	MQ	CS
Wire Feedstock	9.4.1 and 9.4.3	MQ	MQ	CS
AM Procedure Specification	9.5	MQ	CS	CS
Post Processing	9.5.4	MQ	CS	CS
Inspection and Testing	9.7.3	MQ	CS	CS
Prototype Part Qualification	9.6 Table 9.2, 9.3, 9.4	MQ	MQ	CS
Functional Testing	9.6.2	MQ	MQ	CS
Range of Approval	9.6.4	MQ	CS	CS
Part Certification during Production	9.7.4	MQ	CS	CS
Approval for AM Feedstock	Annex 1	MQ	MQ	CS
Manufacturer Approval for AM Final Material	Annex 2	MQ	CS	CS
Approval for AM Repair Facility	Annex 3	MQ	CS	CS

Notes:

1. “MQ” in the table indicates manufacturer qualified requirements determined by the manufacturer, designer and purchaser, which may optionally include the Rules of the *Register* and recognized standard requirements.
2. “CS” in the table indicates approved requirements by the *Register*.

Approval and certificate for an AM part can be issued by the *Register* with documented qualification/production stages in accordance with Table 9.1. The AM process and documentation steps for an AM Part are shown in Table 9.2.

Table 9.2
Process and Documentation Steps

Step 1: Purchaser Specification	<ul style="list-style-type: none"> - Purchaser's Details - Part Design Requirement - Acceptance Criteria - Decision on appropriate AM Level 1, 2, 3 - Additional Requirements by Specification or by Application
Step 2: Qualification Records	<ul style="list-style-type: none"> - Qualified and Documented Procedure with support of Qualified Specific Part and Final AM Material Grade
Step 3: Risk Assessment or Justification	<ul style="list-style-type: none"> - AM Level 3 may require qualification for each specific part - AM Level 2 may accept a part family qualification - AM Level 1 may recognize a qualification of a similar part with the same design feature family
Step 4: Production	<ul style="list-style-type: none"> - Apply Qualified Procedure and Specification - Production - Production Testing - Inspection of Part - Materials Tests for Required Properties by Design - Verify Test Results against Acceptance Criteria
Step 5: Documentation	<ul style="list-style-type: none"> - Accepted with Compliance Record - Engineering Justification for non-conformance, specifically agreed by Purchaser and the <i>Register</i>
<p><i>Notes:</i></p> <p>1. If a part is planned to be repaired, the evaluation plan and acceptance criteria should be agreed with the <i>Register</i> for Level 2 and 3 items.</p>	

9.1.7 References

UR M	Series Machinery Installations
UR S	Series Ship Structure
UR W	Series Materials and Welding
API 20S:2021	Additively Manufactured Metallic Components for Use in the Petroleum and Natural Gas Industries
ASME B46.1:2019	Surface Texture, Surface Roughness, Waviness and Lay
ASME BPVC II C:2023	Specifications for Welding Rods Electrodes and Filler Metals
ASME BPVC. II D Appendix I:2023	Materials Properties – Basis for Establishing Stress Values
ASME BPVC. II D Appendix II:2023	Materials Properties – Basis for Establishing Design Stress Intensity Values
ASME PTB-13:2021	Criteria for Pressure Retaining Metallic Components Using Additive Manufacturing
ASME Y14.100:2017	Engineering Drawing Practices
ASME Y14.36:2018	Surface Texture Symbols
ASME Y14.41:2019	Digital Product Definition Data Practices
ASME Y14.46:2022	Product Design for Additive Manufacturing
ASME Y14.5:2018	Dimension and Tolerancing
ASTM A20:2020	Standard Specification for General Requirements for Steel Plates for Pressure Vessels
ASTM A370:2023	Standard Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM A751:2021	Standard Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
ASTM B213:2020	Standard Test Methods for Flow Rate of Metal Powders Using the Hall Flowmeter Funnel
ASTM B214:2022	Standard Test Method for Sieve Analysis of Metal Powders
ASTM B215:2020	Standard Practices for Sampling Metal Powders
ASTM B311:2022	Standard Test Method for Density of Powder Metallurgy (PM) Materials Containing Less Than Two Percent Porosity

PART 25

AMENDMENTS No. 1

ASTM B822:2020	Standard Test Method for Particle Size Distribution of Metal Powders and Related Compounds by Light Scattering
ASTM B962:2023	Standard Test Methods for Density of Compacted or Sintered Powder Metallurgy (PM) Products Using Archimedes' Principle
ASTM E10:2023	Standard Test Method for Brinell Hardness of Metallic Materials
ASTM E1417:2021	Standard Practice for Liquid Penetrant Testing
ASTM E1444:2022	Standard Practice for Magnetic Particle Testing
ASTM E1570:2019	Standard Practice for Fan Beam Computed Tomographic (CT) Examination
ASTM E1742:2018	Standard Practice for Radiographic Examination
ASTM E18:2022	Standard Test Methods for Rockwell Hardness of Metallic Materials
ASTM E23:2023	Standard Test Methods for Notched Bar Impact Testing of Metallic Materials
ASTM E2651:2019	Standard Guide for Powder Particle Size Analysis
ASTM E3:2017	Standard Guide for Preparation of Metallographic Specimens
ASTM E407:2023	Standard Practice for Microetching Metals and Alloys
ASTM E8:2022	Standard Test Methods for Tension Testing of Metallic Materials
ASTM E92:2023	Standard Test Methods for Vickers Hardness and Knoop Hardness of Metallic Materials
AWS A5.01:2019	Welding Consumables – Procurement of Filler Metals and Fluxes
AWS A5.32:2021	Welding Consumables – Gases and Gas Mixtures for Fusion Welding and Allied Processes
AWS D20.1:2019	Specification for Fabrication of Metal Components using Additive Manufacturing
ISO 10675-1:2021	Non-destructive Testing of Welds – Acceptance Levels for Radiographic Testing – Part 1: Steel, Nickel, Titanium and their Alloys
ISO 10675-2:2021	Non-destructive Testing of Welds – Acceptance Levels for Radiographic Testing – Part 2: Aluminium and its Alloys
ISO 11666:2018	Non-destructive Testing of Welds – Ultrasonic Testing – Acceptance Levels
ISO 14175:2008	Welding consumables – Gases and Gas Mixtures for Fusion Welding and Allied Processes
ISO 17295:2004	Additive manufacturing – General Principles Part Positioning, Coordinates and Orientation
ISO 17636-1:2022	Non-Destructive Testing of Welds – Radiographic Testing – Part 1: X- and Gamma-Ray Techniques with Film
ISO 17636-2:2022	Non-destructive testing of welds – Radiographic testing – Part 2: X- and Gamma-ray Techniques with Digital Detectors
ISO 17637:2016	Non-destructive Testing of Welds – Visual Testing of Fusion- Welded Joints
ISO 17638:2016	Non-Destructive Testing of Welds – Magnetic Particle Testing
ISO 17640:2017	Non-destructive testing of welds – Ultrasonic testing – Techniques, Testing Levels, and Assessment
ISO 23277:2015	Non-destructive Testing of Welds – Penetrant Testing – Acceptance Levels
ISO 23278:2015	Non-destructive Testing of Welds – Magnetic Particle Testing – Acceptance Levels
ISO 31000:2018	Risk Management
ISO 3452-1:2021	Non-destructive Testing – Penetrant testing – Part 1: General Principles
ISO 3954:2007	Powders for Powder Metallurgical Purposes – Sampling
ISO 5817:2014	Welding – Fusion-Welded Joints in Steel, Nickel, Titanium and their Alloys (Beam Welding excluded) – Quality Levels for Imperfections
ISO/ASTM 52900:2021	Additive Manufacturing – General principles – Terminology
ISO/ASTM 52904:2019	Standard for Additive Manufacturing – Process Characteristics and Performance: Practice for Metal Powder Bed Fusion Process to Meet Critical Applications
ISO/ASTM 52905:2023	Additive manufacturing – General principles – Non-destructive Testing of Additive Manufactured Products
ISO/ASTM 52907:2019	Additive manufacturing – Feedstock materials – Methods to Characterize Metallic Powders
ISO/ASTM 52910:2018	Additive Manufacturing – Design – Requirements, Guidelines and Recommendations
ISO/ASTM 52911-1:2019	Additive Manufacturing – Technical Design Guideline for Powder Bed Fusion - Part 1: Laser-Based Powder Bed Fusion of Metals
ISO/ASTM 52911-3:2023	Additive Manufacturing – Technical Design Guideline for Powder Bed Fusion - Part 3: Electron-Based Powder Bed Fusion of Metals
ISO/ASTM 52922:2020	Guide for Additive Manufacturing– Design – Directed Energy Deposition
ISO/ASTM 52924-4:2023	Additive Manufacturing of Metals – Qualification Principles – Part 4: Qualification of Machine Operators for DED-LB

ISO/ASTM 52924-5:2023	Additive Manufacturing of Metals – Qualification Principles – Part 5: Qualification of machine operators for DED-Arc
ISO/ASTM 52926- 1:2023	Additive Manufacturing of Metals – Qualification Principles – Part 1: General Qualification of Machine Operators
ISO/ASTM 52926- 2:2023	Additive Manufacturing of Metals – Qualification Principles – Part 2: Qualification of Machine Operators for PBF-LB
ISO/ASTM 52926- 3:2023	Additive Manufacturing of Metals – Qualification Principles – Part 3: Qualification of Machine Operators for PBF-EB
ISO/ASTM 52935:2023	Additive manufacturing – Qualification principles – Qualification of Coordinators for Metallic Parts Production
ISO/ASTM 52943- 2:2023	Standard Guide for Directed Energy Deposition of Metals
ISO/ASTM 52950:2021	Additive Manufacturing – General principles – Overview of Data Processing

9.2 Abbreviations and Definitions

9.2.1 Abbreviations

AM	Additive Manufacturing
AMF	Additive Manufacturing Format
AMPS	Additive Manufacturing Procedure Specification
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
API	American Petroleum Institute
AWS	American Welding Society
BJT	Binder Jetting
CAD	Computer Aided Design
CT	Computerized Tomography
DED	Directed Energy Deposition
EB	Electron Beam
GMA	Gas Metal Arc
GTA	Gas Tungsten Arc
HIP	Hot Isostatic Pressing
ISO	International Organization for Standardization
ITP	Inspection and Testing Plan
LB	Laser Beam
NDT	Non-destructive Testing
OEM	Original Equipment Manufacturer
PT	Liquid Penetrant Testing
PA	Plasma Arc
PBF	Powder Bed Fusion
PWHT	Post Weld Heat Treatment
SDS	Safety Data Sheet
QMS	Quality Management System
QR	Qualification Records
QP	Quality Procedure
STEP	Standard for the Exchange of Product Model Data
STL	Standard Tessellation Language
SWI	Standard Work Instruction
WAAM	Wire Arc Additive Manufacturing
3MF 3D	Manufacturing Format
UR IACS	Unified Requirement
Rec.	IACS Recommendations

9.2.2 Definitions

Acceptance criteria	A set of values or criteria which a design, product, service or process is required to conform with, to be considered in compliance
AM facility	Equivalent to AM manufacturer, which is considered as an entity with the capability of making an AM final part/component/material following a qualified process to meet the requirements by the client or purchaser
Approval	The granting of permission for a design, product, service or process to be used for a stated purpose under specific conditions based upon a satisfactory appraisal by the <i>Register</i>

PART 25

AMENDMENTS No. 1

Audit	Planned systematic and independent examination to determine whether the activities are documented, that the documented activities are implemented, and that the results meet the stated objectives
Brown part	A brown part is a green part which has been heated and/or chemically treated to remove the binding material. It is a body ready to be sintered/infiltrated to become a final part.
Certificate	A formal document attesting to the compliance of a design, product, service or process with defined acceptance criteria
Certification	A procedure whereby a design, product, service or process is approved in accordance with defined acceptance criteria
Class/Classification society	Short for <i>Register</i>
Class approval	An AM material/part which is to be manufactured at a works approved by the <i>Register</i>
Classification	A specific type of certification, which relates to the Rules of the relevant <i>Register</i>
Component	A part or member of some equipment or a system
Conformity	Where a design, product, process or service demonstrates compliance with defined specific requirements
Design	All relevant plans, documents, calculations described in the performance, installation and manufacturing of a product
Defect	One or more flaws whose aggregate size, shape, orientation, location or properties do not meet specified acceptance criteria and are rejectable.
Design analysis	Investigative methodology selectively used to assess the design
Design review and approval	Part of the appraisal process to evaluate specific aspects of the design including drawing or solid model review and approval supported by the final material specification
Green part	A green part is a body that is made of powdered material that has been compressed and is held together with a binding material
Equivalent	An acceptable, no less effective alternative to the specified criteria
Essential Parameters	Any parameter is considered to be essential when any aspect falling outside the qualified range affects the mechanical properties or final part quality. Essential parameters are to be defined in the specification and are required to be reviewed and surveyed. Any change of essential parameters outside the qualified range requires requalification.
Infiltration	A process of filling the pores of an un-sintered or sintered object with a metal or alloy of lower melting point than that of the object
Installation	The assembling and final placement of components, equipment and subsystems to permit operation of the system
Manufacturer	The party responsible for the manufacturing and quality of the product
Manufacturing process	Systematic series of actions directed towards manufacturing a product
Manufacturing process approval	Approval of the process whereby a manufacturer produces a part using additive manufacturing
Modification	A limited change that does not affect the current approval
Part, specific	A specific part or component with the same geometric requirements, material requirements and function requirements.
Part, family	A family of parts (or similar parts) with the same function requirements, material requirements and same design features or shape but different size or section thickness.
Part, similar	A similar part with similar function requirements, the same material requirements and similar design features including different shape, size, thickness.
NDT indication	A response from a reflector during an NDT test that can further be classified as relevant or non-relevant, and usually requires further evaluation to determine its acceptability against the specified acceptance criteria.
Performance test	A technical operation where a specific performance characteristic is determined
Prototype test	Investigations on the first or one of the first new parts for optimization, fine tuning of equipment/system parameters and verification of the expected running behavior
Qualified or Qualification	The granting of permission for a design, product, service or process to be used for a stated purpose under specific conditions based upon satisfactory appraisal by the manufacturer
Repair	Restore to original or near original condition from the results of wear and tear or damage for a product or system in service

Reverse Engineering	A process to disassemble and examine or analyze in detail (a product or device) to discover the concepts involved in manufacture, usually to produce something similar (a product or device). i.e. AM building a new product by scanning an existing product. Consideration of intellectual property (IP) issues should be addressed on a case-by-case basis.
Sintering	A thermal treatment of a powder or compact, at a temperature below the melting point of the main constituent, for the purpose of increasing its strength by the metallurgical bonding of its particles
Specification	Technical data or particulars which are used to establish the suitability of materials, products, components or systems for their intended use. The specification could be provided by the manufacturer or purchaser and should be agreed by the purchaser
Witness	An individual physically present at a test and being able to record and give evidence about its outcome. Remotely present may be specially agreed by the <i>Register</i> .

9.3 Design Requirements

9.3.1 General

The quality and performance of the AM part should be considered for part design requirements and the material requirements, with appropriate control of essential parameters during the manufacturing process including pre-build, build and post-build.

The additive manufacturer should prepare a product design package, refer to Table 9.3, including additive manufacturing procedures, specifications in accordance with the purchase specification, the purchase order including all the requirements for the fabrication of all built parts, etc.

Table 9.3
Product Design Package

No.	ITEM
1.	Standards, or Manufacturer/OEM's Specifications
2.	AM Level (1, 2 or 3)
3.	Revision controlled drawing, CAD model or digital build file including test coupons (for reference)
4.	The applicable material specification with acceptance criteria for each intended part/application
5.	Design analysis report, if applicable
6.	Powder/wire/binder specification
7.	AM pre-build, build and post-build specification/procedure
8.	Inspection and Testing Plan
9.	Any other specifications, requirements or procedures identified as necessary by the additive manufacturer or purchaser

Part solid model/drawing and materials specifications should be qualified in accordance with Section 9.6 and included in the qualification records in accordance with the applicable subsection 9.3.2 and 9.3.3.

The qualified specifications and procedures for the AM part should be followed and retained in the additive manufacturer's production records.

9.3.2 Drawing or Solid Model

Part design includes the creation of the part drawing or solid model for end-use and should consider the achievable material properties defined in the final material specification.

The CAD model or drawing for the final AM part should include requirements for final geometry, dimensions, and tolerances in accordance with an internationally recognized industry standard, e.g.: ASME Y14.46:2018, Y14.41:2019, Y14.5:2018.

If the CAD model or drawing for the final AM part is redesigned, optimized by topology, or generated by design algorithms, the CAD model for the final AM part should be calculated or simulated using engineering software to verify design compliance and integrity for service. The design analysis report including the applicable procedure and results should be submitted for review by the Class Society for Level 3.

PART 25

AMENDMENTS No. 1

The optimized design requirements for the final AM part should demonstrate at least an equivalent level of functionality and integrity, such as the capability to withstand the applied loads or the applied environmental conditions to traditionally manufactured parts, which the Class Society should accept and approve for Level 3, and could accept and approve for Levels 1 and 2.

The revision number of the solid model, drawing or digital build file should be included in the AM part approval and included in manufacturer’s production records.

9.3.3 Material Specification

Refer to Table 9.4, the material specification should include all material properties, including the specified AM process, for the final delivered condition and the acceptance criteria for the AM part or material. The selected material specification/grade with the heat treatment condition should be identified in the final AM material specification.

Depending on the intended application, the acceptable material properties should provide equivalency to traditional manufactured materials in accordance with applicable IACS UR W, Rec., or alternatively with internationally recognized industry standards or the designer’s specifications.

Due to the inherent morphology of the AM process, consideration may be given to use an AM material with alternative chemistry and enhanced mechanical/corrosion properties, which are equivalent to or exceed the material properties typically required in the service condition, such as impact, fatigue, wear, or corrosion resistance. The selected final AM material should be appropriate for the loading condition, the functionality, the environment, and should be approved by the *Register* as an alternative new manufacturing method for the specified part/application.

The following items in Table 9.4 should be specified in the AM material specification for the final delivered condition. In the case of AM materials for AM Level 3, the material specification, including the following items in Table 9.4, should be submitted to the *Register* for approval.

Table 9.4
Final Material Specification

No.	ITEM
1.	Material type and grade
2.	Manufacturing process, including the AM process and any post-build heat treatment process
3.	Chemical composition
4.	Microstructure, such as grain size, and metallographic analysis
5.	Fusion density, applicable to powder processes and not required for wire DED
6.	Tensile properties
7.	Charpy impact properties and test temperature, if required, according to the design temperature and material grade
8.	Hardness tests, if required
9.	Other special properties such as fatigue, fracture mechanics properties, corrosion, erosion, or wear resistance, if required for the intended application
10.	Non-destructive testing methods, test level, quality level, and acceptance criteria
<i>Notes:</i> 1. Microstructure, fusion density and special properties are required during qualification/approval but are optional for production.	

9.4 Feedstock Specification

9.4.1 General

The feedstock supplier should maintain a quality management system, which should, at least, meet the minimum requirements in accordance with internationally recognized quality standards such as ISO 9001:2015.

Feedstock material should be qualified using feedstock materials approval tests in accordance with Annex 1, referred to in subsection 1.6 v).

If approval is already granted by other Classification Societies, evidence of the approval together with documentation of performed approval tests should be submitted. The indicated approval tests in Annex 1 could be reduced with the agreement of the *Register*.

9.4.2 Powder Feedstock

9.4.2.1 Powder Feedstock Specification

For powder feedstock material specification, documentation, handling, and storage, internationally recognized industry standards, such as ISO 17296-2:2015, ISO/ASTM 52907:2019, can be referred to by the manufacturer.

Refer to Table 9.5, the powder specification should be defined with the applicable powder manufacturing process and the range of essential parameters. Refer to Table 9.6, the nonessential parameters should be indicated for information.

Unless otherwise agreed the powder specification could be qualified for certified items by the manufacturer and should be approved for class items by the *Register*, to a range of parameters, refer to Annex 1. Any change of essential parameters outside the qualified range requires requalification. The essential parameters for powder feedstock include the following items in Table 9.5:

Table 9.5
Essential Parameters for Powder Feedstock

No.	ESSENTIAL PARAMETERS FOR POWDER FEEDSTOCK
1.	Material grade
2.	Powder manufacturing process, including the melting and atomization process, type of gas used, environmental conditions.
3.	Post-atomization process, such as sieving.
4.	Chemical composition
5.	Powder size range
6.	Particle size distribution
7.	Powder morphology and internal microstructure
8.	Flowability
9.	The applicable additive manufacturing process (e.g., powder for PBF-LB, powder for PBF-EB, powder for DED, or powder for BJT)

Non-essential parameters for powder feedstock include the following items in Table 9.6:

Table 9.6
Non-essential Parameters for Powder Feedstock

No.	NON-ESSENTIAL PARAMETERS FOR POWDER FEEDSTOCK
1.	Density, such as apparent density, tap density, skeletal density, and fusion density
2.	Thermal properties, such as solidus, liquidus temperature for reference
3.	Oxygen content
4.	Moisture content, etc.
5.	The applicable additive manufacturing process (e.g., powder for PBF-LB, powder for PBF-EB, powder for DED, or powder for BJT)

The manufacturer should ensure that feedstock materials comply with all local and national regulations for environment, handling and safety.

9.4.2.2 Powder Feedstock Documentation

The powder supplier should issue a statement of conformity in accordance with the additive manufacturer's powder feedstock specification. For each powder lot and/or batch supplied, the powder supplier shall document, for raw material control and traceability, the information given in Table 9.7:

PART 25

AMENDMENTS No. 1

Table 9.7
Documentation for Powder Feedstock

No.	ITEM
1.	Procurement information (Powder should be sourced from a feedstock supplier approved by the Class Society for class items.)
2.	Powder supplier’s contact information
3.	Lot and Batch Number
4.	Powder description
5.	Powder manufacturing process, including the melting and atomization process, type of gas used, environmental conditions
6.	Post-atomization process, such as sieving
7.	Sampling methods such as chute splitting, blending or spin riffing
8.	Testing method, standard, and results required by the powder material specification
9.	Packing date, quantity, handling requirements, shelf life and storage instructions
10.	SDS
<p><i>Notes:</i></p> <p>1. The control of powder feedstock is by Lot Number and Batch Number. Powder from the single Lot Number and single Batch Number indicates that quantity of feedstock produced under traceable and controlled conditions from a single manufacturing process cycle. The size of the feedstock lot is determined by the feedstock supplier. A single powder lot is used as feedstock in build cycles. Powder from the single Lot Number and multiple Batch Number indicates that quantity of feedstock produced under traceable and controlled conditions from a single manufacturing process cycle. The remaining feedstock of insufficient quantity to complete the build cycle that has been used in multiple AM machines is combined, blended and used to finish the powder lot. Powder from multiple Lot Numbers indicates that more than one powder lot is used as feedstock in build cycles. Multiple lots are usually blended before being loaded into the feed region.</p> <p>2. Samples taken for testing should be representative of the powder lot, ensuring homogeneity when split. ASTM B215 can be referred to for sampling of metallic powders subject to a prior customer/supplier agreement. The sampling method(s) should be reported. For sampling metal powder, the preferred method is to use a dynamic sampling technique like chute splitting or spin riffing to ensure a representative sample is collected by dividing the powder stream while it is flowing, minimizing segregation issues that can occur with static sampling methods.</p>	

9.4.2.3 Powder Recycling

Powder should be protected against damage, contamination, and deterioration during handling, storage, and recycling. For the DED powder process, only powder which has not exited the DED nozzle may be recycled.

For the PBF or applicable BJT processes, powder recycling with mixed lots is not allowed. Powder recycling for the same lot may be allowed in accordance with procedures agreed by the Class Society. Procedures for powder recycling may consider the following factors in Table 9.8:

Table 9.8
Factors for Powder Recycling

No.	FACTORS
1.	The documented methods for tracking the progression of powder recycling
2.	Limitation for powder recycling times
3.	Performance of the final delivered material property by the recycled powder
4.	The documented control procedures, such as sieving, blending, testing oxygen, moisture, or other practices
5.	Test results of the essential parameters should be within the specified range of virgin powder, if applied
6.	Implementation of procedures for prevention of cross contamination on multimaterials use by one machine. Alternatively, linking one machine for one type of material

9.4.3 Wire Feedstock

9.4.3.1 Wire Feedstock Specification

For wire feedstock, internationally recognized industry standards such as AWS A5.01:2019, AWS A5.32:2021, ASME BPVC. II. C:2023 or other equivalent standards such as ISO 14175:2008 can be referred to by the manufacturer.

The wire specification should be defined including the manufacturing process and the acceptable range for the essential parameters in Table 9.9. Any non-essential parameters should be indicated for information in the procedure qualification record specified in subsection 9.5.5.

Unless otherwise agreed, the wire specification should be qualified for certified items by the manufacturer or approved for class items by the *Register*. Qualification should include the acceptable range for the parameters. Any change of the following essential parameters outside the qualified range requires requalification.

Table 9.9
Essential Parameters for Wire Feedstock

No.	ESSENTIAL PARAMETERS
1.	Material grade
2.	Mechanical properties
3.	Chemical composition
4.	Wire size
5.	Tolerance and surface condition (Ra) throughout the length
6.	The applicable additive manufacturing process for which the wire feedstock can be used

9.4.3.2 Wire Feedstock Documentation

The wire material supplier should issue a statement of conformity and document the following information in Table 9.10 for raw material control and traceability per lot per batch.

Table 9.10
Documentation for Wire Feedstock

No.	INFORMATION
1.	Wire should be sourced from a feedstock supplier approved by the <i>Register</i> for class items.
2.	Wire supplier’s contact information
3.	Lot and Batch Number
4.	Wire description such as wire size, material grade, AWS designation, F No., A No. if applicable
5.	Wire manufacturing process
6.	Associated shielding gas
7.	Testing method and results as required by the wire specification
8.	Packing date, quantity, and instructions for handling, storage, incoming control
9.	As-built properties and Post Weld Heat Treatment (PWHT) properties, if applicable
10.	SDS

9.4.4 Binder Feedstock

If required, the binder feedstock specification should be qualified by the AM facility. The following factors in Table 9.11 should be specified or considered by the manufacturer.

PART 25

AMENDMENTS No. 1

Table 9.11
Factors for Binder Feedstock

No.	FACTORS
1.	Material grade
2.	Chemical composition
3.	Viscosity
4.	Surface tension
5.	Thermogravimetric analysis
6.	Flash point
7.	Evaporation temperature
8.	Curing temperature
9.	Storage, handling, and expiration date, if applicable
<p><i>Notes:</i> 1. Additional factors which should be considered during binder selection include: deposition method, compatibility with building process, interaction between binder and powder, effects on the strength of the as-built part, stability, and burnout characteristics.</p>	

The binder feedstock is a secondary material, which is a liquid bonding agent or glue that binds the metal/ceramic particles together. The binder feedstock can affect the binder jetting and sintering/infiltration process but should not affect the quality of the final part. The final material properties and part dimensions should be achieved by the post-build sintering/infiltration process. The qualification of binder materials should be documented by the AM facility and submitted to the *Register*, if deemed necessary.

9.5 Additive Manufacturing Procedure Specification (AMPS)

9.5.1 General

The AMPS should be documented by the additive manufacturer for controlling and monitoring both the essential parameters and non-essential parameters that may affect the final part quality.

The AMPS should be qualified using a range of parameters in association with the approval tests by the *Register*. Any change of essential parameters beyond the range should be requalified. Test witnessing is required for class items and certified critical items.

The applicable essential and non-essential parameters should be documented by the AM facilities/manufacturers. Any parameter that influences heat source/input and heat deposition/history should be considered as an essential parameter.

The additive manufacturing procedure should be included in the additive manufacturer’s production records.

9.5.2 Pre-Build Procedure

The following pre-build process characteristics in Table 9.12 should be defined and identified, which may be supported by slicing software for the preparation of the manufacturing procedure:

Table 9.12
Pre-build Process Characteristics

No.	PRE-BUILD PROCESS CHARACTERISTICS
1.	Part location and orientation
2.	Test coupon location and orientation
3.	Machining allowance for part and test coupon, if applicable
4.	Build location and nesting, if applicable
5.	Build surface, direction, and gravity direction, if applicable
6.	Support/infill structure, if applicable
7.	Appropriate cleaning procedure for build platform
<p><i>Notes:</i></p> <ol style="list-style-type: none"> Part orientation should be identified relative to a specified build surface, such as the build platform or incorporated substrate. If applicable or required, the build location should be identified using X, Y, Z directions in accordance with internationally recognized industry standards, such as ISO 17295:2023. For PBF or applicable BJT processes, the part may be oriented and optimized using pre-build software, to reduce the build time or thermal residual stress. For PBF processes, the location of a single part may be specified within a build envelope. Multiple build locations may be necessary when multiple parts are built simultaneously within the same building envelope. For DED processes, parts may be oriented vertically, horizontally or to other angles determined by machine flexibility to manipulate the substrate. Test coupons should be identified in the build layout with a unique label. If the build layout and build surface are depicted, the build location, orientation, and related tolerance for test coupons are also to be indicated in accordance with internationally recognized industry standards such as ISO 17295:2023. Digital build models of parts and test coupons should be submitted for reference as part of the submission. For PBF or applicable BJT processes, test coupons may be built as near-net-shape test samples or test samples could be retrieved from the sufficient test blocks. For DED processes, test coupons may be taken from a prolonged part/artifact, or a separate test block that represents the part features or part section thickness, which can be specially considered and agreed to by the <i>Register</i>. For PBF or applicable BJT processes, overhangs and sacrificial support structures may be applied for support during fabrication, if required. Alternatively, the part may be reoriented during the building process to avoid overhang if this is possible. If specified, a bounded surface or volume region may be used to define locations to limit or require support/infill structure. If not specified, a default support/infill structure may be applied depending upon the machine and software. 	

Internationally recognized industry standards, such as ISO/ASTM 52950:2021, may be referred to for an overview of data processing. Digital files may include derivatives from the original CAD model (e.g., STL, AMF, STEP or 3MF).

Digital build files should be accurately exported, especially for the critical features, documented and submitted for information, if deemed necessary by the Class Society. During exporting digital building files, the conversion of digital building file from solid model to machine recognized model/code should be verified and any errors should be fixed automatically by available software or manually by the operator.

9.5.3 Build Procedure

9.5.3.1 General

Building parameters related to heat source/input, refer to subsection 9.5.3.2 for PBF processes and 9.5.3.3 for DED processes, and heat deposition/history, refer to subsection 9.5.3.2 for PBF processes and 9.5.3.3 for DED processes, are considered as essential parameters and should be specified in the procedure specification, controlled, and qualified within the range.

Non-essential operating parameters identified by experience or fixed parameters imposed by the machine system should be documented and controlled as much as possible, including the build platform, build environment, and any other related parameters.

If process characteristics are required for in-process monitoring during building, those requirements should be monitored for conformance, such as machine building errors, failures, or defect inspection.

9.5.3.2 Powder Bed Fusion (PBF)

For powder processes, internationally recognized industry standards, such as ISO/ASTM 52904:2019, can be referred to by the manufacturer for inclusion in the procedure specification.

PBF-EB has similar capabilities as PBF-LB but demonstrates differences due to different beam sources. Compared with PBF-LB, the beam energy transferred by the electron beam is higher.

PART 25

AMENDMENTS No. 1

The process may operate at higher temperatures, with faster build rates and relatively lower resolutions. Additionally, the powder bed is preheated to slightly below melting temperature, which results in less thermally induced stress.

The parameters in Table 9.13 should be defined in the PBF-LB or PBF-EB procedure specification.

Table 9.13
Additive Manufacturing Procedure Specification for PBF Process

No.	ITEM
1.	Heat Source: a) Beam type, such as laser or electron beam b) Beam power c) Beam size d) Beam frequency or waveform control e) Beam splitting f) Beam focus setting
2.	Deposition: a) Layer thickness b) Scan pattern/strategy c) Travel speed d) Hatch overlap, distance/spacing e) Specific settings control for edges or surfaces
3.	Build Environment for PBF-LB: a) Build platform material specification/designation, thickness, surface finish, dimension, parallelism, and tolerance b) Build platform preheat temperature c) Shielding gas composition and flow rate d) Supplemental gas shielding e) Build chamber gas composition f) Environmental enclosure hardware and configuration
4.	Build Environment for PBF-EB: a) Build platform material specification/designation and thickness b) Build platform preheat temperature c) Vacuum pressure d) Build Environment
5.	Other Parameters: a) Re-coater blade type, material, or roller wear b) Powder dosing rate c) Ambient environmental conditions d) Feedstock condition, such as powder lot, batch number, virgin or recycled

9.5.3.3 Directed Energy Deposition (DED)

For DED processes, internationally recognized industry standards, such as ASTM F3187:2016, can be referred to by the manufacturer for inclusion in the procedure specification. The parameters in Table 9.14 should be defined in the DED procedure specification.

Table 9.14
Additive Manufacturing Procedure Specification for DED Process

No.	ITEM
1.	Heat Source: a) Type of beam/arc b) Beam/arc power c) Beam/arc size d) Heat pulse frequency or waveform control e) Preheating by beam splitting (not applicable to PA-DED, GTA-DED, and GMA- DED) f) Use of energized (pre-heated) wire (not applicable to Powder DED) g) Beam/arc focus setting (not applicable to PA-DED, GTA-DED, and GMA-DED)
2.	Deposition: a) Programmed layer thickness (applicable to laser powder DED, not applicable to other DED processes) Scan pattern/strategy b) Scan pattern/toolpath c) Travel speed d) Hatch overlap, distance/spacing (applicable to laser powder DED, not applicable to other DED processes) e) Feed rate f) Start working distance/nozzle standoff distance (not applicable to PA-DED, GTA-DED, and GMA-DED) g) Specific settings that may affect edge and surface build condition h) Wire delivery parameters such as incidence angle, offset distance or path orientation (not applicable to powder DED) i) The applied techniques such as weaving, multi-wires or pulse for wire DED, if applicable j) Start and stop point
3.	Build Environment: a) Build platform material specification/designation, thickness, surface finish, dimension, and tolerance b) Build platform preheat temperature c) Inter-pass temperature and inter-pass cleaning, if applicable d) Shielding gas composition and flow rate (not applicable to EB-DED) e) Powder carrier gas flow rate (applicable to powder DED) f) Supplemental gas shielding (not applicable to EB-DED) g) Supply gas composition (not applicable to EB-DED) h) Build chamber gas composition, if applicable i) Vacuum pressure (applicable to EB-DED only) j) Environmental enclosure hardware and configuration
4.	Other Parameters: 1. Orientation of heat source impingement 2. Ambient environment conditions, such as temperature, moisture, etc. 3. Feedstock type, such as powder or wire
Notes: 1. If the substrate is integrated within the final part, the mechanical and metallurgical properties at the bonding interface, together with any inspection requirements, should be included in the qualification tests. The substrate for qualification should be representative of the substrate for production.	

9.5.3.4 Binder Jetting (BJT)

The main parameters in Table 9.15 should be defined in the BJT or equivalent procedure specification.

These factors are the AM build parameters, which should be controlled for the dimensions of the green part. The final dimensions and quality are determined by the sintering/infiltration process of the brown part.

PART 25

AMENDMENTS No. 1

Table 9.15
Main Parameters for BJT Process

No.	MAIN PARAMETERS FOR BJT
1.	Layer thickness
2.	Powder spread, if applicable
3.	Build speed
4.	Binder saturation, if applicable
5.	Drying time and heater powder ratio, if applicable
6.	Build orientation
7.	Travel strategy

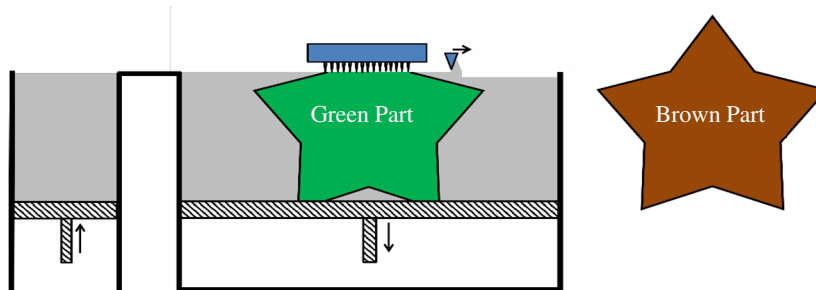


Figure 9.2
Schematic for Binder Jetting Process

9.5.3.5 In-Process Monitoring or Controlling

Some AM systems may have subsystems using one or more real-time sensors to monitor or control various performance and status indications during building, such as melt pool temperature, size, lack of fusion, spattering, and other parameters.

If subsystems can change or can control any qualified essential parameters, subsystems should be included in the AMPS and are required in qualification records, including details of the monitoring or controlling type and method, monitoring or controlling system settings and the qualified essential parameters. Subsystems are not required in AMPS and qualification records, if they do not change or do not control any qualified essential parameters.

9.5.4 Post-Build Procedure

9.5.4.1 General

The post-build process required to meet the quality and properties of the final delivered part should be provided in documented procedures or specifications.

The parameters such as temperature, soak time, and cooling media should be specified and controlled by the heat treatment facility. Reference should be made to industry standards depending upon materials.

If specified, allowances for machining could be referred to internationally recognized industry standards or manufacturer’s practices.

The same post-build heat treatment processes should be applied to the test coupons and the sacrificial/actual parts if the post-build process affects the final delivered material properties or is defined as an essential parameter.

9.5.4.2 Powder Removal

The manufacturer’s procedure should include a process for removal of loose powder from parts manufactured by PBF or BJT processes. The residual powder in the part may cause health and safety issues for personnel while working during the post processing steps, especially for reactive materials such as titanium-based or aluminum-based powder. Any health and safety risks should be identified and either designed out or minimized.

9.5.4.3 Heat Treatment

Heat treatment, where specified, should be in accordance with Class Rules, internationally recognized industry standards, or best practice suited to the materials, refer to the same traditionally manufactured material grade. To avoid distortion, the part should be adequately supported during heat treatment as appropriate for the component shape/complexity.

9.5.4.4 Part Removal

Procedures should be prepared by the manufacturer for part removal or support structure removal. The following information in Table 9.16 should be documented:

Table 9.16
Procedure for Part Removal

No.	ITEM
1.	Suitable build platform temperature when the part is planned to be removed from build chamber
2.	If applicable, powder removal needs to be verified before heat treatment
3.	Applicable methods and tools, such as band saw, slow speed saw, manual tools, machining, grinding etc.
4.	Step-by-step instructions

Generally, to reduce residual stress, stress relief heat treatment should be carried out before the part is removed. However, this might not be applicable for large parts due to the furnace capacity. Therefore, there are some cases where parts may be removed before stress relief heat-treatment. Depending upon materials, special attention to avoid cracking may be required and this should be specially considered and agreed to by the *Register*.

The removal of support structures should be done in a manner to avoid detrimental impact on the part. This can be proactively considered during design for the ease of removal of the interface between the support structure and the part.

9.5.4.5 Surface Finish or Machining

Surface finishing is important for fatigue, non-destructive testing, maintaining tolerance, surface texture and appearance. Surface finish should be in accordance with the manufacturer’s procedure. Surface finishing or additional machining operations should be performed after the applicable heat treatment processing due to potential deformation and discoloring/oxidization during heat treatment.

9.5.5 Additive Manufacturing Procedure Specification Qualification

Refer to Table 9.17, the purpose of procedure qualification is to demonstrate the capabilities of an AM procedure to produce a specific AM build component, AM feedstock, AM final material, or repair part by an AM process to meet the requirements.

The AM procedure specification (AMPS) should document the required variables to ensure the repeatability of the AM process. Procedure qualification records should document the data recorded during qualification testing, including the applied parameters and corresponding test results.

Qualification records for AMPS should be established and documented for review and survey when approval is requested for an AM part, AM feedstock, AM manufacturers for final material, AM repair facilities, refer to Table 9.17.

The qualification procedure of an AM repair facility, as described in Annex 3, requires both a procedure specification and documented qualification records. See also subsection 9.10.4 for repair of an AM Part.

PART 25

AMENDMENTS No. 1

Table 9.17
Additive Manufacturing Procedure Specification Qualification

Qualification records for AMPS	
ITEM	DETAIL
AM Part	The qualification procedure for an AM part, as described in Section 9.6, requires the procedure specification and the documented qualification records for the delivered part and should meet all the design requirements in Section 9.3.
AM Feedstock	The qualification procedure for AM feedstock, as described in Annex 1, requires the procedure specification and documented qualification records to meet the requirements for the final delivered feedstock material in subsection 9.3.3.
AM Manufacturer	The qualification procedure for an AM manufacturer for final material, as described in Annex 2, requires the procedure specification and documented qualification records for the final delivered material and should meet the acceptance criteria in subsection 9.3.3.
AM Repair	The qualification procedure for an AM repair facility, as described in Annex 3, is applicable when using an AM process for repair of in-service damaged parts. The part(s) will require a procedure specification and documented qualification records.

9.6 Additively Manufactured Prototype Part Qualification

9.6.1 General

A generic procedure qualification for prototype parts is required in accordance with subsection 5.5.

Refer to Table 9.18, AMPS and qualification records for part approval should be documented with revision control. Evidence should be provided that the technical/design requirements are achievable for the required application.

Table 9.18
Additively Manufactured Prototype Part Qualification

AMPS and qualification records for part approval	
No.	DETAIL
1.	Test coupons and a prototype AM part should be built in the same build batch using the established digital build volume model including part location and orientation, support structure, machining stock, and the test sample's location and direction to meet the same specifications as for production.
2.	Test coupons should represent the actual part or the worst-case scenario, such as edge of build platform in the Z direction for laser-based process.
3.	As applicable, the height/length of each separately built tensile specimen in the Z direction should be at least the maximum height of the intended part for the PBF or applicable BJT process. If not applicable for a large part/component, the standardized tensile sample with 50 mm (2 in.) gauge length should be tested or multiple tensile samples should be tested in the Z direction to cover the height/length of the large part/component.
4.	As applicable, for DED processes the samples should be retrieved from the prolongation of the intended part to replace the sacrificial part tests, considering that prolongation has similar dimensions (e.g., section thickness of the part). For separate coupons, the test samples should represent the intended part and features. For PBF process, the samples can be built separately from the intended part and at least one sample should be built for each laser zone, if applicable.
5.	The relationship between controlled/specified process parameters as inputs and test results as output, in accordance with the part model and the materials specification, should be established by qualification records for the specific combination of parameters.
6.	The relationships of dimensions and material properties between test coupons and the intended AM part should be established. The test coupons are used to assist quality control continuity during fabrication or production.
7.	The test coupons and the specific part are to achieve the required properties by approval tests in accordance with applicable IACS UR's, Class Rules, industry standards, or designer/OEM specification.

9.6.2 Approval Tests for Prototype Part

The prototype part qualification for approval includes materials tests such as mechanical tests, metallurgical tests, non-destructive tests and functional tests. If the prototype part is built by an approved additive manufacturer in accordance with Annex 2, a reduced scope for mechanical and metallurgical testing could be agreed by the *Register*.

Unless otherwise agreed, the test samples, methods, and test quantity denoted in Table 9.19 for PBF processes, Table 9.20 for DED processes and Table 9.21 for BJT or equivalent processes should be followed.

Charpy impact testing may be specially considered and agreed to by the *Register*, depending upon materials, design temperature, and build process.

Depending upon the intended parts and applications, supplementary tests may be required, such as for fatigue, fracture mechanics, corrosion, wear, erosion, weldability, and residual stress measurements.

Depending on the application, function tests could be proof load tested for a load bearing part, pressure/leak tested for a pressure bearing part or balance tested for a rotary machinery part etc.

Alternative approval test samples, methods, and quantities may be accepted by the *Register* provided that the AM manufacturer submits explanations showing that they are technically similar.

Table 9.19
Approval Tests for Powder Bed Fusion Process

Sampling	Types of Tests	AM Level 1	AM Level 2	AM Level 3 for Class
		Certified and Non-Critical	Certified and Critical	
Test Specimen	Visual Inspection	Yes	Yes	Yes
	Surface Flaw Inspection	Yes	Yes	Yes
	Embedded Flaw Inspection	By Agreement	By Agreement	By Agreement
	Chemistry	Feedstock certificate	AM built coupon	AM built coupon
	Tensile	1	3	5
		1 in Z at one corner	3 in Z (diagonal 2 corners and 1 center)	5 in Z (4 corners and 1 center)
	Impact, if applicable	By Agreement	1 set	3 sets
			1 set in Z, at corner	1 set in Z, 1 set in X and 1 set in Y, at corner
	Hardness	By Agreement	3	6
			1 at 1/8 below surface, 1 at 1/4 thickness, 1 at center	2 at 1/8 below surface, 2 at 1/4 thickness, 2 at center
Microstructure	By Agreement	2	4	
		1 in Z and 1 in X/Y	2 in Z and 2 in X/Y	
Density	Optional – to be agreed	3	5	

PART 25

AMENDMENTS No. 1

Sampling	Types of Tests	AM Level 1	AM Level 2	AM Level 3 for Class
		Certified and Non-Critical	Certified and Critical	
Component Tests	Visual Inspection	Yes	Yes	Yes
	Surface Flaw Inspection	Yes	Yes	Yes
	Embedded Flaw Inspection	By Agreement	Yes	Yes
	Hardness Tests	If Applicable	If Applicable	If Applicable
	Function Tests	Yes	Yes	Yes

Notes:

- For PBF-EB processes, tensile and Charpy test directions and quantities could be specially considered and agreed to by the Register.
- X, Y, Z is the direction of the build, refer to internationally recognized industry standards.
- Number count refers to the number of test specimens to be taken in each location, e.g. tensile '1 in Z at one corner' equates to "1 tensile test in the Z direction taken from one corner".

Table 9.20
Approval Tests for Directed Energy Deposition Process

Sampling	Types of Tests	AM Level 1	AM Level 2	AM Level 3 for Class
		Certified and Non-Critical	Certified and Critical	
Test Specimen	Visual Inspection	Yes	Yes	Yes
	Surface Flaw Inspection	Yes	Yes	Yes
	Embedded Flaw Inspection	By Agreement	By Agreement	By Agreement
	Chemistry	Feedstock certificate	AM built coupon	AM built coupon
	Tensile	1	3	6
		1 in Z	3 in Z	3 in Z, 3 in X or Y
	Impact, if applicable	By Agreement	1 set	3 sets
			1 set in Z	1 set in Z, 1 set in X and 1 set in Y
	Hardness	By Agreement	3	6
			1 at 1/8 below surface, 1 at 1/4 thickness, 1 at center	2 at 1/8 below surface, 2 at 1/4 thickness, 2 at center
	Microstructure	By Agreement	2	4
			1 in Z and 1 in X/Y	2 in Z and 2 in X/Y
Density, if powder DED	By Agreement	3	3	
Bend, if wire DED	By Agreement	4	4	
		2 in Z and 2 in X/Y	2 in Z and 2 in X/Y	

Sampling	Types of Tests	AM Level 1	AM Level 2	AM Level 3 for Class
		Certified and Non-Critical	Certified and Critical	
Component Tests	Visual Inspection	Yes	Yes	Yes
	Surface Flaw Inspection	Yes	Yes	Yes
	Embedded Flaw Inspection	By Agreement	Yes	Yes
	Hardness Tests	If Applicable	If Applicable	If Applicable
	Function Tests	Yes	Yes	Yes

Notes:

- For part approval by DED processes, reference or sacrificial parts are applicable for approval tests in lieu of test coupons. X, Y, Z is the direction of the build, refer to internationally recognized industry standards.
- If the DED procedure is qualified for an integrated build platform, the AM part or material should not be removed from the build platform for the final delivered condition. As a minimum, six tensile samples should be retrieved and tested for each integrated build platform material. Three tensile samples should represent the interface and heat affected zone (HAZ). The other three samples should represent the AM build materials in the gauge length. Charpy tests for integrated build qualification could be specially considered and agreed to by the *Register*. The interface and HAZ should be characterized and documented, with reference to traditional welding procedure qualification. Two bend tests in the Z and two bend tests in the X or Y direction for wire arc DED processes should be included for the integrated build component for AM Level 2 and AM Level 3 during the qualification stage.
- Number count refers to the number of test specimens to be taken in each location, e.g. tensile ‘1 in Z’ equates to “1 tensile test in the Z direction”.

Table 9.21
Approval Tests for Binder Jetting or Equivalent Process

Sampling	Types of Tests	AM Level 1	AM Level 2	AM Level 3 for Class
		Certified and Non-Critical	Certified and Critical	
Test Specimen	Visual Inspection	Yes	Yes	Yes
	Surface Flaw Inspection	Yes	Yes	Yes
	Embedded Flaw Inspection	By Agreement	By Agreement	By Agreement
	Chemistry	Feedstock certificate	AM built coupon	AM built coupon
	Tensile	1	2	3
		1 in any direction	1 in Z and 1 in X/Y	Agreed direction
	Impact, if applicable	By Agreement	1 set	2 sets
			1 set in Z, any location	1 set in Z, 1 set in X/Y, any location
	Hardness	By Agreement	3	3
Microstructure	By Agreement	1	1	
Density	By Agreement	3	3	

PART 25

AMENDMENTS No. 1

Sampling	Types of Tests	AM Level 1	AM Level 2	AM Level 3 for Class
		Certified and Non-Critical	Certified and Critical	
Component Tests	Visual Inspection	Yes	Yes	Yes
	Surface Flaw Inspection	Yes	Yes	Yes
	Embedded Flaw Inspection	By Agreement	Yes	Yes
	Hardness Tests	If Applicable	If Applicable	If Applicable
	Function Tests	Yes	Yes	Yes

Notes:

- Number count refers to the number of test specimens to be taken in each location, e.g. tensile '1 in any direction' equates to "1 tensile test taken in the X, Y, or Z direction".

9.6.3 Information to be Submitted for Final Approval and Certification by the Register

The following documents in Table 9.22 should be submitted for AM part approval, for review and survey by the Register:

Table 9.22
Information to be Submitted for Additively Manufactured Part Final Approval and Certification

No.	ITEM
1.	Documentation identifying the part as either a class part or certified part
2.	AM Level 1, 2, or 3
3.	If applicable, CAD model or drawing for the final AM part and supporting engineering calculations or simulations for the model
4.	If applicable, a digital build model of the part and test coupons for building, including orientation, support structures, etc., for reference
5.	Evidence of approval for the AM manufacturer for class items or evidence of certification of the AM manufacturer by an appropriate inspection body for certified items
6.	Final material specification including material grade, composition, properties requirements, and the NDT test standard and acceptance criteria
7.	Evidence of approval of the feedstock material for class items or evidence of certification of the feedstock material by an appropriate inspection body for certified items
8.	The AM procedure specification
9.	The post-build procedure specification
10.	Qualification records for the part approval, including inspection and testing results with traceability of applied parameters
11.	Functionality testing procedures and results
12.	Agreed plan for installation, operation, and survey
13.	Inspection and test plan for the part certification during production, refer to Section 9.7.

9.6.4 Range of Approval

Refer to Table 9.23, the range of approval should consider the combination of the qualified model and procedures/specifications:

Table 9.23
Range of Approval for AM Part

No.	ITEM
1.	Documentation identifying the part as either a class or a certified part
2.	AM Level (1, 2, or 3)
3.	CAD model or drawing with revision number
4.	Materials specification of final delivered condition
5.	AM machine model
6.	Feedstock material linked to feedstock supplier
7.	AM procedure specification including pre-build, build and post-build
8.	The intended application of the finished part (e.g., the equipment/system in which the part is to be installed)

Approval of AM Level 3 parts, such parts may be qualified and approved with the support of the qualification record of a specific part.

Approval of AM Level 2 parts, a family of parts may be qualified and approved with the support of a risk analysis for the part family and/or with simulation model results, both of which should be specially considered and agreed to by the *Register*.

Approval of AM Level 1 parts, a similar part may be qualified and approved with the support of a risk analysis for the design feature family and/or with simulation model results, both of which could be specially considered and agreed by the *Register*.

Notes:

- .1 *Requalification should be carried out if there are any quality concerns for the delivered part or if there are any changes as defined in Section 9.7.*
- .2 *Supplementary tests can be carried out and recorded to expand the range of approval. To extend the range of approval from AM Level 1 to AM Level 2, the manufacturer should complete the additional tests specified for AM Level 2.*
- .3 *To extend the range of approval from AM Level 1 to AM Level 3 or AM Level 2 to AM Level 3, the manufacturer should complete the additional tests specified for AM Level 3.*
- .4 *Additional testing for expanding the range of approval may also include the supplementary tests specified in Section 9.6.2.*

9.7 Production

9.7.1 General

During production, the approved, certified, classed parts should follow the qualified AMPS requirements for feedstock, pre-build, build and post-build. The inspection and testing reports should be documented by batch control and included in the additive manufacturer’s production records to provide evidence that part design requirements have been achieved during the manufacturing process.

Notes:

- .1 *The production batch is to be randomly selected and tested to represent all parts/components with the same batch feedstock, the same equipment, the same operator, the same process parameters, and the same post-processing.*

PART 25

AMENDMENTS No. 1

9.7.2 Qualified Additive Manufacturing Process Specifications

Production for approved or certified parts with batch control should be completed following the steps in Table 9.24.

Table 9.24
Qualified Additive Manufacturing Process Specifications for Production

Step No.	ITEM	
1.	Items/functions to be Qualified:	CAD model or drawing or digital build model with revision number
2.	Qualified:	Feedstock material specification linked to feedstock supplier by contractual agreement
3.	Qualified:	AM procedure specification
4.	Qualified:	Post-build heattreatment procedure/specification, if applicable
5.	Items/functions to be verified by manufacturer and customer as agreed:	Machine maintenance, qualification, and calibration, operator knowledge - practices and qualification, the applicable essential and non-essential parameters, pre-build check of the digital file, test coupons, machine hardware and software, sufficient raw materials for the build cycle, planned or un-planned interruption etc.
6.	Inspection and testing plan (ITP) to be agreed:	The test scope for production control should be included in the ITP agreed by the purchaser and manufacturer. As a minimum, the test scope for AM Level 1 should be included in the ITP. Other applicable tests in subsection 9.6.2 could be added based on design requirements and the intended service environment. The test scope for AM Level 2 and Level 3 should be appropriately adjusted to a higher test frequency, quantity or extent above the test scope defined for Level 1. This should be defined in the purchase specification, and specifically considered and agreed to by the <i>Register</i> .

9.7.3 Inspection and Testing

The inspection and testing should verify that the technical design requirements and function requirements are met repeatedly, accurately, and consistently using representative parts and/or testing coupons through non-destructive or destructive testing methods.

The inspection and testing of representative parts and/or test coupons should be performed after all post-build processes. Material testing should be carried out after heat treatment and may exclude machining and surface finishing. NDT should be carried out with appropriate machining and surface finishing.

Testing should be in accordance with the *Section 2 Test specimens and mechanical testing procedures for materials*, applicable Class Rules, industry standards, or designer/OEM specifications for quality control during production.

The frequency of production testing should follow the agreed ITP, referred to Table 9.24 Step 6.

9.7.3.1 Chemical Composition

The chemical composition should be analyzed in accordance with internationally recognized industry standards such as ASTM A751, and the results should be documented including all elements. The chemical composition should meet the requirements of the materials specification of the final delivered condition, see subsection 9.3.3.

9.7.3.2 Microstructure

Samples should be prepared in accordance with internationally recognized industry standards. The microstructure after the final heat treatment should be examined using optical microscopy or scanning electron microscopy (SEM). The following information in Table 9.25 should be documented for qualification and production if required.

Table 9.25
Documentation for Material Microstructure

No.	INFORMATION
1.	Sample ID
2.	Part thickness at sectioning plane
3.	Sectioning plane angle relative to build platform
4.	Pictures at a quarter and half thickness with different magnifications, such as 5X, 100X, 500X or in line with the facility’s procedures
5.	Reported description of microstructure with grain size or other observation
6.	Characterization of flaws or defects, such as morphology, type, size, location, frequency, if applicable

9.7.3.3 Tensile Properties

Tensile properties should be tested in accordance with the *Section 2 Test specimens and mechanical testing procedures for materials* and internationally recognized industry standards such as ASTM E8:2022. Subsize samples are acceptable for PBF or applicable BJT processes with a minimum gauge diameter of 6.25 mm (0.25 in.) according to ASTM E8:2022. Other alternative sample sizes may be specially considered and agreed to by the *Register*.

At least one tensile test, preferably in the Z orientation, should be carried out and the test results should be reported in accordance with ASTM F2971-13:2021 and documented for qualification and production including, as a minimum, the items in Table 9.26.

Table 9.26
Documentation for Tensile Properties

No.	ITEM
1.	Tensile sample information such as identification, gauge length, diameter for round samples or width and thickness for flat samples, and the sample orientation
2.	Test temperature should be stated if it is not room temperature
3.	Test results such as yield strength, ultimate tensile strength, elongation, reduction of area, and tensile failure type and location
<p><i>Notes:</i></p> <p>1. At elevated temperatures different tensile properties to those at room temperature may be specified as additional requirements by the materials specification. If specified, tensile properties should be carried out in accordance with with the <i>Section 2 Test specimens and mechanical testing procedures for materials</i> and internationally recognized industry standards, such as ASTM E8:2022.</p> <p>2. If required by the design, tensile properties may be tested at a defined temperature above the design temperature for the intended part application.</p> <p>3. If required, the acceptance criteria for elevated temperature tensile properties should be defined in material specification for the final delivered condition.</p>	

9.7.3.4 Impact Properties

If required by material specification, at least one set of Charpy V-Notch impact tests should be carried out in accordance with the *Section 2 Test specimens and mechanical testing procedures for materials*. Test results should be documented and include the following items in Table 9.27.

PART 25

AMENDMENTS No. 1

Table 9.27
Documentation for Impact Properties

No.	ITEM
1.	Charpy sample information such as identification, sample size, and notch orientation
2.	Test temperature
3.	Test results for qualification and production such as absorbed energy, crystallinity percentage, and lateral expansion
4.	Ductile to brittle transition temperatures if required during qualification

9.7.3.5 Hardness

Three hardness tests can be applied for quality control in accordance with the manufacturer's procedure. These could be the Brinell Hardness test, the Rockwell Hardness test, the Vickers hardness test or other applicable hardness testing methods in accordance with internationally recognized industry standards. Hardness can also be a finished product design requirement.

9.7.3.6 Bend Test

If required, two bend tests should be carried out. Bend test sample size and bending mandrel can refer to the bend tests required for welding procedure qualification, or other internationally recognized industry standards.

9.7.3.7 Special Properties

Other special properties may need testing during qualification depending upon the material specification and intended application, which may include fusion density, fatigue properties, corrosion properties, wear, erosion, fracture toughness, high or low temperature properties, etc.

The inspection and testing plan and testing procedures should be submitted to the *Register* for review. Test results should be documented for qualification. The sampling of special properties for production control, including frequency and quantity, should be in accordance with the approved or agreed test plan.

Weldability testing may need to be performed depending on the fabrication, installation, and build process, etc. If welding is planned, specific testing will be considered and agreed to by the *Register*.

9.7.3.8 Non-destructive Testing**9.7.3.8.1 General**

The final delivered part should be non-destructively tested by NDT personnel certified to the appropriate level of a nationally recognized scheme for the applied techniques, such as those schemes specified in the Rules, *Part 26 Welding, Section 2.4 Requirements for NDT Suppliers*. A surveyor witness is required for NDT processes for classification and certification. The NDT timing (delayed time between NDT starting and completion of fabrication) should be considered, refer to the Rules, *Part 26 Welding, Section 2.5 Non-destructive testing of ship hull steel welds* and *Section 2.6 Advanced non-destructive testing of materials and welds*, which may be material dependent.

The extent of NDT should be in accordance with the agreed NDT plan.

For class items, NDT should be carried out in accordance with the Rules, *Part 26 Welding, Section 2.5 Non-destructive testing of ship hull steel welds* (conventional NDT techniques) and *Section 2.6 Advanced non-destructive testing of materials and welds* (advanced NDT techniques) and meet the corresponding product standards, e.g., *IACS Recommendation No. 68 Guidelines for non-destructive testing of hull and machinery steel forgings* (Work instruction *QW73 Non-destructive testing of hull and machinery steel forgings* respectively), *IACS Recommendation No. 69 (Guidelines for non-destructive testing of hull and machinery steel forgings* (Work instruction *QW74 Non-destructive testing of marine steel castings* respectively) or other standards acceptable to the *Register*. The requirements for NDT suppliers, including certified operator and supervisor levels, should follow the Rules, *Part 26 Welding, Section 2.4 Requirements for NDT Suppliers*.

For certified items, NDT should be carried out in accordance with recognized national/international standards and meet the design specification.

9.7.3.8.2 Visual Examination

100% visual examination is required. The acceptance criteria should follow internationally recognized industry standards and the purchaser's specification, and should include surface finish, tolerance, and dimensions.

9.7.3.8.3 Surface Flaw Examination

Surface examination should follow the applicable NDT techniques in the *Rules for the classification of Ships, Part 26 Welding*, Section 2.5 Non-destructive testing of ship hull steel welds or Section 2.6 Advanced non-destructive testing of materials and welds. The as-built surface of AM part may give false indications, so, where surface NDT is required, the surface should be made suitable for the NDT method applied.

9.7.3.8.4 Embedded Flaw Examination

Conventional ultrasonic or radiographic inspection should refer to the *Rules for the classification of Ships, Part 26 Welding*, Section 2.5 Non-destructive testing of ship hull steel welds. Further guidance on NDT is given in IACS Recommendation No. 68 Guidelines for non-destructive testing of hull and machinery steel forgings (Work instruction QW73 Non-destructive testing of hull and machinery steel forgings respectively) and IACS Recommendation No. 69 (Guidelines for non-destructive testing of hull and machinery steel forgings (Work instruction QW74 Non-destructive testing of marine steel castings respectively), for products corresponding to equivalent forged or cast components. Advanced NDT should refer to the *Rules for the classification of Ships, Part 26 Welding*, Section 2.6 Advanced non-destructive testing of materials and welds. Computerized Tomography (CT) scan may be applied where defined in the project specifications.

9.7.3.8.5 In-Situ Process Monitoring

In-situ process monitoring can be a viable method for qualification/production control, which can partially/fully replace surface or embedded flaw inspection, depending on the criticality level and the agreed ITP.

Before adoption in production, the in-situ process monitoring technology should be verified and validated, by suitable NDT techniques, with supporting data, in conjunction with agreed inspection quality levels, test levels and acceptance criteria. The acceptance of in-situ process monitoring for inspection could be qualified and agreed by the *Register*.

GUIDANCE NOTES FOR WHERE IN-SITU PROCESS MONITORING IS APPLIED:

- .1 The in-situ process monitoring model-based approach should apply the in-situ sensor data to monitor the AM build process. Methods and algorithms such as machine learning models may be utilized to calibrate and map layer-wise images to laser scan vectors. Images/Spectral/Data are stacked and exported to standardized 3D data formats to enable easy inspection and comparison to post-build a 3D CT or UT/RT surface or embedded flaw. Procedures are to be in place to address discrepancies between in-situ indications as identified during process monitoring and subsequent NDT results, including additional diagnostic scanning or other verification measures.
- .2 The in-situ process monitoring model can be validated using the data captured by high-resolution CT scans as verified data (actual flaw location and size).
- .3 NDT indications or defects, e.g. gas porosity, keyhole pores, lack of fusion, is classified or categorized by outputs/resultant data of the machine learning model, if applicable.
- .4 Unless otherwise agreed, the probability of detection for in-situ process monitoring should meet the 90%/95% reliability of flaw detection. e.g. 100 layers were selected for analysis and detection of flaws in 90 layers can meet the lower bound of 95% confidence interval for the defined flaw size in accordance with the acceptance criteria of the applicable sections of the *Rules for the classification of Ships, Part 26 Welding*, Section 2.5 Non-destructive testing of ship hull steel welds and Section 2.6 Advanced non-destructive testing of materials and welds, ISO 5817:2023, ISO 10675-1:2021, ISO 10675-2:2021 or equivalent standards, which may depend on the section thickness of the part. In-situ flaw detection procedures should be documented, and capability should be supported by procedure verification and validation results.
- .5 When in-situ process monitoring is adopted during initial qualification and production, repeatability and data detection should be verified, and results should be analyzed, with at least 10% of the cross-validated data verified by the traditional or advanced NDT techniques. (e.g. 10 parts use an in-situ process for flaw detection, at least 1 part should be inspected using traditional or advanced NDT techniques). To accept in-situ process monitoring for small-batch or one-off critical parts, the *Register* may require a higher percentage of cross-checking, commensurate with the criticality of the component and the agreed ITP.

9.7.4 Part Certificate

A part certificate should be issued by the *Register* for class. Certificates for certified items should be issued by the manufacturer and should be supported by the manufacturer's documents in accordance with 9.7.2 and 9.7.3 as applicable. Unless otherwise agreed, certification should be furnished for the final delivered part by the additive manufacturer indicating:

- a) Material grade
- b) Chemical composition
- c) Reference to the Additive Manufacturing Procedure Qualification Record
- d) Tensile test results
- e) Charpy test results, if applicable
- f) Hardness, if applicable
- g) Nondestructive test results
- h) Any additional specialized test results
- i) Function test results, if applicable
- j) Other intermediate processes such as heat treatment, surface finish, machining conditions

PART 25

AMENDMENTS No. 1

9.8 Non-Conformance

If parts do not conform to the specified requirements, non-conformance reports should be generated, documented, and maintained by the additive manufacturer. Parts may be accepted or rejected with or without reworking based on engineering justification, which should be agreed to by the *Register* and purchaser.

The manufacturer should keep a record of all non-conformities, where warranted, and should carry out root-cause investigations, if systematic errors are identified within any part of the process or components.

9.9 Documentation

The following items in Table 9.28 should be documented by the manufacturer in accordance with the quality management system/program and provided as production records with full traceability.

Table 9.28
Documentation for Production Records

No.	ITEM
1.	AMPS with revision control including the feedstock specification, the final material specification, and the procedure (pre-build, build and post-build) specification
2.	Drawing, solid model, software or digital build file with revision control
3.	Type Approval Number or Feedstock test report
4.	Additive manufacturing procedure qualification report
5.	Part certificate
6.	Any other part/application specific tests including test results and acceptance criteria
7.	Any non-conformance reports

9.10 Identification, Retesting and Surveys

9.10.1 Identification

The manufacturer should adopt a system for the identification of AM parts e.g. build batch number control, which will enable the parts to be traceable to the applied AM process and test report, and the Surveyor should be given full facility access for tracing the material when required.

9.10.2 Retesting

Material retesting for parts subject to classification requirements should follow the Rules. For certified parts, material retesting may be specifically agreed. Test results for the original test and retest should be reported for class and certified parts.

9.10.3 Surveys

Surveyor witness for functional testing, such as pressure or proof load tests, is required for class and certified critical parts during the prototype part qualification stage and may be required for class parts during production. Functional testing could be carried out at a workshop or on-board, subject to a factory acceptance test and/or a site acceptance test as specified in the approved ITP or contract agreement. Surveyor witness after installation should be agreed in accordance with the applicable requirements.

A surveyor witness for material testing is required for class and certified parts during the prototype qualification stage. During the production stage, surveyor witness for material testing is required for a class part but is optional for a certified part.

Notes:

- .1 *AM parts may need additional survey when in service, when compared to traditionally manufactured parts. This may be required because AM parts do not yet have sufficient marine service history. This should be identified early on as part of the design and build philosophy.*

9.10.4 Repair for AM Part

Unless otherwise agreed, repair of an AM class part is prohibited without approval by the purchaser and the *Register*.

If repair of the AM part during production is needed, repair procedures and the method for repair should be suitably established and agreed to by the *Register* prior to repair.

9.11 Repair of AM Part Damaged In-service

If repair of an AM class part in service is needed, repair procedures and the method for repair should be suitably established and agreed to by the original additive manufacturer or AM repair facility and the *Register* prior to repair, refer to Annex 3.

For the repair of non-class AM parts damaged in service, the repair procedure and the method of repair should be according to the applicable specifications per industry standards, designer/OEM requirements, refer to Annex 3.

ANNEX 1: APPROVAL FOR ADDITIVE MANUFACTURING FEEDSTOCK

1 General

Annex 1 provides recommendations for the approval of additive manufacturing feedstock materials by the *Register* for a feedstock supplier approval. The recommendations can also be used for feedstock qualified by the AM manufacturer for an AM manufacturer approval and applied under a commercial agreement between the two parties, the AM manufacturer and the feedstock supplier.

If the traditionally manufactured parts are class items, feedstock materials should be approved by the *Register*. For certified items, the approval for feedstock materials could be agreed by purchase specification.

Approval for feedstock materials involves a documentation review, an audit of the facility and the witness of approval tests. Unless otherwise agreed, the Class approval is valid subject to annual verification and/or endorsement by the attending Surveyor. An additional audit may be requested at annual verification.

2 Approval Application

Approval should be requested by the client, along with the information and a detailed inspection and test plan (ITP) as listed in Table 9.29.

Table 9.29
Approval Application for Additive Manufacturing Feedstock

No.	ITEM
1.	An outline of the organization including the quality management system, a facility description, details of organization and quality control responsibilities
2.	Manufacturing process description or flow charts indicating all process steps
3.	A list of documented manufacturer's procedures, specifications, documentation, reports and product certificates
4.	Documented procedures for feedstock identification and traceability using lot control and batch control
5.	Documented historical data for parts built using the feedstock, if available
6.	Inspection and testing plan (ITP)

3 Feedstock Specification and Qualification

3.1 General

An additive manufacturing feedstock specification should be prepared for each material grade for which approval is requested. Prior to conducting approval tests, the feedstock specification and ITP should be submitted and approved by the *Register*/AM manufacturer.

3.2 Feedstock Specification Approval

The feedstock specification should be submitted to the *Register*/AM manufacturer for review and approval. A description and specification of the feedstock should be prepared in accordance with 4.2.1 for a powder feedstock specification together with the following notes and with 4.3.1 for a wire feedstock specification.

Notes:

- .1 *ISO 3954:2007 or ASTM B215:2020 can be referred to for powder sampling. The material grade may be a trade name, common name, or typical material designation.*
- .2 *The chemical composition is to be tested and determined by a suitable testing procedure such as wet chemical process, atomic absorption spectrometry, flame emission spectroscopy, X-ray fluorescence analysis, or other*

PART 25

AMENDMENTS No. 1

recognized methods. Industry standards may be referenced to determine the content of interstitial elements such as carbon, nitrogen, hydrogen, sulphur, and oxygen.

- .3 Powder size and distribution are to be tested in accordance with ASTM E2651:2019 or other equivalent standards, such as sieving in accordance with ASTM B214:2022 for DED powder, static or dynamic image analysis, light scattering, laser diffraction in accordance with ASTM B822:2020 or other recognized methods. The powder size distribution (PSD) may be described by D10, D50 and D90. D10 is the first decile (e.g., 1/10 of the statistical population is below this value). D50 is the median value (e.g., 50% of the statistical population is below this value). D90 is the last decile (e.g., 90% of the statistical population is below this value). Other powder size distribution methods may also be specified by the powder manufacturer. For a powder DED process, the maximum powder size may be specified depending upon the powder feeding system.
- .4 Morphology can be affected by the powder manufacturing process. The preferred inspection method is by scanning electronic microscopy (SEM), secondary electron imaging, or other recognized methods.
- .5 Flowability can be affected by multiple factors such as powder size and distribution, cohesive strength by moisture, inter-particles friction, powder sphericity, etc. Industry standards, such as ASTM B213:2020, may be referenced to test flowability through piping, nozzle, funnel, etc.

3.3 Approval Tests

Unless otherwise agreed, the following approval tests should be carried out and test results should be reported using AM built test coupons in accordance with subsection 7.3 for inspection and testing. The results should be included in qualification records. Refer to Table 9.30. Test coupons should represent the performance of the feedstock.

Table 9.30
Approval Tests and Test Results for Additive Manufacturing Feedstock

No.	TEST ITEMS
1.	Visual inspection: Sample ID and results
2.	Dimension inspection: Sample ID and results
3.	Surface flaw inspection: Sample ID and results
4.	If specified, embedded flaw inspection: Sample ID and results
5.	3 tension tests: Sample ID, sample orientation, sample size and test results including yield strength, tension strength, failure type and location
6.	If required, 1 set of Charpy impact tests, applicable to materials with ductile-to- brittle transition: Sample ID, sample orientation, sample size and test results
7.	If applicable, bend tests: 2 bend tests in the Z and 2 bend tests in X or Y direction for wire arc DED processes and test results
8.	Hardness test for the interface cross-section and heat affected zone (HAZ) in the substrate for an integrated build: Sample ID, hardness values or hardness profile from AM build material to HAZ
9.	Microstructure examination: Sample ID, part thickness at the section plane, section plane angle relative to build platform, magnification, and results
10.	Chemical analysis: Sample ID and results
11.	Density test: Sample ID and results
12.	Other tests: other tests may be performed if the manufacturer assesses them to be useful for qualification of the feedstock or if they are specified by the powder purchaser.

4 Survey

4.1 Initial Survey

The manufacturer should be audited by the attending Surveyor. The initial survey of feedstock production facilities should include witness of the feedstock manufacturing process, survey of manufacturing control for repeatability of the AM feedstock quality, evaluation of the quality management system, document control for the manufacturing procedure and specification, and quality control for sampling, testing, reporting, etc.

4.2 Witness of Approval Tests

The approval tests should be witnessed by the attending Surveyor of the Register.

4.3 Annual Survey

The annual survey should be carried out by the attending Surveyor. The annual survey should include a plan to demonstrate the essential parameters are followed during production. During the annual survey, full or partial approval tests could be requested based on the performance of the annual production record.

5 Information to be Submitted for Approval by the Class Society

For class parts, the following items in Table 9.31 should be submitted to the Class Society:

Table 9.31
Approval Tests and Test Results for Additive Manufacturing Feedstock

No.	ITEM
1.	Operator qualifications record
2.	Feedstock material specification and documentation
3.	Recommend AM build parameters for the feedstock material
4.	Types of approval tests, test standards and test results in accordance with Annex 1/3.3
5.	Witness of the qualification approval tests
6.	Qualification records with a certifying statement acknowledging the validity of the data and certifying the qualification tests and test results
7.	Agreed plan for quality control during feedstock production

6 Range of Approval

Upon satisfactory completion of the feedstock specification review and survey, approval will be granted by the *Register*. The following information is to be stated in the approval certificate issued by the *Register*:

- a) Feedstock supplier
- b) Qualified feedstock material specification in accordance with subsection 4.2.1 for powder feedstock and subsection 4.3.1 for wire feedstock

ANNEX 2: APPROVAL FOR MANUFACTURER - ADDITIVELY MANUFACTURED METALLIC MATERIALS

1 General

For class items, the manufacturer should be approved in accordance with this Annex 2. For certified items, the approval of the manufacturer should be agreed by a purchase specification.

Manufacturers should comply with the applicable requirements in their quality management system. The machine, procedure and personnel should be qualified and documented. The procedure should be followed during production by the manufacturer.

The manufacturer should prepare the manufacturing specifications/procedures, qualified using approved tests of qualification build block or coupons. The manufacturing specifications/procedures should be approved with repeatedly and consistently achievable AM final materials properties.

Manufacturers should be evaluated with reference to both quality management system and AM capability. In addition, the sub suppliers or outsourcing of any services or production should be reviewed by using a specification/procedure. The sub suppliers or outsourcing may include a feedstock supplier, a post-build heat treatment shop, a machine shop, a laboratory for testing, NDT facilities, or service supplier.

Class approval involves a documentation review, an audit of the facility/manufacturer and witness of the approval tests. Unless otherwise agreed, the approval is valid for a maximum of 5 years subject to annual verification and/or endorsement by the attending Surveyor. Renewal approval should be requested and issued with the effective date being the 5 years anniversary date from the previous approval. An additional audit may be requested if there is any quality concern.

2 Approval Application

Approval should be requested by the AM manufacturer, and submitted with the information listed in Table 9.32 and a detailed inspection and test plan (ITP).

PART 25

AMENDMENTS No. 1

Table 9.32
Approval Application for Manufacturer - Additively Manufactured Metallic Materials

No.	SUBMITTED DOCUMENTS
1.	An outline description of the manufacturer including their quality management system (see subsection 2.1.1), a facility description (see subsection 2.1.2), and details of the manufacturer’s organization and quality control (see subsection 2.1.3)
2.	Additive manufacturing capability (see subsection 2.2)
3.	Documentation for manufacturing equipment (see subsection 2.3)
4.	Documentation for operators (see subsection 2.4)
5.	A list of documented manufacturing procedure specifications, supporting documentation and test reports and the/any AM product/part/material certificates
6.	Inspection and testing plan for qualification and production
7.	Documented procedures for incoming feedstock materials identification and traceability using batch control
8.	Documented historical data for previously built AM final parts or materials

2.1 Description of Manufacturer

2.1.1 Quality Management System (QMS)

The review and survey of the AM manufacturer by the *Register* should cover the facility description, organization, quality, and AM capability and should include any historical data for the AM manufacturer approval, to the satisfaction of the *Register*. A formal QMS in accordance with an internationally recognized standard is not mandatory, however, the AM manufacturer is to have a QMS in place which is documented, controlled, auditable, and embedded in the organizational structures.

2.1.2 Facility Description

General information for the facility should include the following items in Table 9.33.

Table 9.33
Description for the Facility

No.	GENERAL INFORMATION FOR THE FACILITY
1.	Name and address of AM facility
2.	General relevant information and background
3.	Estimated annual production of finished parts for AM products, and a brief description of intended applications

2.1.3 Organization and Quality

High level organization should provide the following items in Table 9.34.

Table 9.34
Organization and Quality

No.	ITEM
1.	Organizational chart
2.	Organization of the quality control department and the staff employed
3.	Qualification of the operators involved in activities related to the quality of the part/material
4.	Certification of compliance with the quality system with internationally recognized industry standards, where applicable
5.	A management system of engineering specifications, procedures with revision control, and documentation for part/sample labelling and traceability
<i>Notes:</i>	
1.	The manufacturers should take responsibility for feedstock quality, storage, handling and re-use, if applicable.

2.2 Additive Manufacturing Capability

The following items in Table 9.35 should be provided for AM capability.

Table 9.35
Additive Manufacturing Capability

No.	ITEM
1.	Approval certificates/documentation already granted by the Class Society, if any
2.	List of machines and materials/parts for approval
3.	Manufacturing flow chart for the AM Process
4.	Feedstock handling and storage procedure
5.	Final delivered part/material handling and storage procedure
6.	Details of the various equipment used or outsourcing facilities, including pre-build, AM build, and post-build activities (e.g., furnace, condition and recording method of heat treatment)
7.	Non-destructive and destructive testing facilities or service suppliers intended to be used, if outsourced
8.	Information about the different types of material grades the facility intends to manufacture, with frequency of manufacturing, and any previous examples
9.	Information about the different types of AM processes the facility intends to use to fabricate parts with the manufacturing frequency and any previous examples
10.	Previous examples of the different types of test coupons/manufactured parts at the facility
11.	Information about maximum weights, dimensions, section thickness the facility is capable of handling
<i>Notes:</i>	
1.	The manufacturers should take responsibility for feedstock quality, storage, handling and re-use, if applicable.

2.3 Documentation for Manufacturing Equipment

The manufacturer should establish and document evidence to demonstrate the following items in Table 9.36 (refer to internationally recognized industry standards depending upon the AM process).

PART 25

AMENDMENTS No. 1

Table 9.36
Documentation for Manufacturing Equipment

No.	ITEM
1.	An outline description of the manufacturer including their quality management system (see subsection 2.1.1), a facility description (see subsection 2.1.2), and details of the manufacturer’s organization and quality control (see subsection 2.1.3)
2.	Additive manufacturing capability (see subsection 2.2)

The written quality procedures and machine qualification records should be documented for equipment calibration, maintenance, monitoring, and control by the manufacturer in their quality management system and submitted to the *Register* if deemed necessary.

Documentation of a machine should include the following information in Table 9.37.

Table 9.37
Documentation for AM Machine Qualification

No.	DOCUMENTATION ITEMS
1.	Machine manufacturer
2.	Machine model
3.	Serial number
4.	Any additional components which impact build parameters
5.	Software version
<i>Notes:</i>	
1. Any changes to the above items should be documented as a change of machine. Any change should be linked to a machine model number. A serial number for the same machine model number is not considered as a change of machine. If multiple machines with different serial numbers are used, they should be separately documented.	

2.4 Documentation for Operators

Operators should be competent with documented practical experience and knowledge tests (such as written exams, internal training, external training, certification by the third party, or a combination of these factors).

The operator should have the appropriate competence of understanding of the qualified additive manufacturing procedure specification (AMPS) and operating practices in accordance with the approved procedures for the part or material qualification builds.

For practical skills, the operator should demonstrate the necessary process steps on the machine and demonstrate the necessary capabilities to follow a preliminary/qualified AM procedure specification.

For the procedure, part and material qualification or production, the operator should be assessed based on the practical qualification/approval tests in accordance with the requirements of the procedure for material approval and/or part approval tests and as specified in the manufacturer’s operating procedures.

The range of documentation for the operator should include the combination of process, feedstock material and machine, refer to Table 9.38.

Table 9.38
Documentation for Manufacturing Equipment

ITEM	DETAIL
Metal AM process	Change of process should be requalified.
Feedstock material group	Change of material group should be requalified.
Machine	Change of machine should be requalified.

The written quality procedures and operator performance/qualification records should be documented and managed by the manufacturer in their quality management system and available to the Class Society, as requested.

3 Approval Tests for Additive Manufacturer

A procedure should be qualified to produce AM final material/part. General requirements in subsection 5.5 are applicable to the AM facility/manufacturer/materials qualification. Additional procedure qualification requirements for the approval of additive manufacturers are included in this Annex with AM final materials properties in accordance with subsection 3.3 for final material specification.

AMPS and qualification records should be established by specification and documentation control to demonstrate that the material requirements meet the technical/design requirements in accordance with Class Rules, industry standards, or the designer/OEM specification.

Sufficient test coupons for the final delivered condition should be prepared for all qualification tests. Repeatability should be demonstrated and agreed to by the *Register*, refer to Table 9.39.

Table 9.39
Approval Tests for Additive Manufacturer

No.	TEST COUPONS
1.	Test coupons with or without a sacrificial/actual part should be built using standard qualification builds and should achieve the required material properties confirmed by approval tests.
2.	For PBF or applicable BJT processes, test samples for approval tests should be evenly distributed on the overall build platform and represent a worst-case scenario for samples during production.
3.	For DED processes, test samples should represent the intended section thickness such as thin and thick test blocks.
4.	Test samples should represent the intended AM part and applications or worst- case scenario, such as edge of the build platform with fast cooling rate.
5.	The relationship between input variables and output results should be established for the specific combination of parameters by qualification records for manufacturer approval.
6.	Test quantities could be specially considered and agreed by the Class Society, if the AM facility/manufacturer can provide historical test results for the technically same combination of machine, feedstock, procedure, and final material of the final delivered condition.

If part approval and facility approval are carried out concurrently, the procedure qualification for part approval and facility approval should be combined in one build batch. The test methods, quantities, and acceptance criteria for approval tests should meet the requirements, whichever is more stringent.

Approval tests, test methods, and acceptance criteria should be related to the material specification of the final delivered condition and agreed to before testing samples are prepared. Test coupons should represent the performance of the overall build envelope. Alternative tests may be specially considered and agreed to by the *Register*.

Unless otherwise agreed, the following approval tests should be carried out and test results should be reported using the AM built test coupons in accordance with 7.3 for inspection and testing and included in the qualification records, refer to Table 9.40.

PART 25

AMENDMENTS No. 1

Table 9.40
Documentation for Manufacturing Equipment

TYPES OF TESTS	RECORDED ITEMS IN TEST RESULTS
Visual inspection:	Sample ID and results
Dimension inspection:	Sample ID and results
Surface flaw inspection:	Sample ID and results
Embedded flaw inspection:	Sample ID and results
Tensile tests:	3 in Z (refer to ASME PTB-13:2021) and 3 in X/Y including sample ID, sample orientation, sample size and test results including yield strength, tension strength, failure type and location
Charpy tests for materials with ductile-to-brittle transition (if applicable):	3 sets of Charpy impact test including sample ID, sample orientation, sample size and test results
Bend tests for wire arc DED processes (if applicable):	2 in the Z and 2 in X/Y direction
Microstructure examination:	Sample ID, part thickness at the section plane, section plane angle relative to build platform, magnification, and results
Chemical analysis:	Sample ID and results
3 fusion density tests for powder feedstock:	Sample ID and results
Residual stress measurement (if applicable and required):	Sample ID and results
Other tests:	Other tests may be performed depending on material grade or intended application, such as fatigue test, corrosion test or weldability test.
<i>Notes:</i>	
1. Additional Charpy tests may be requested by the purchase specification at a different test temperature, such as 20 oC below the specified temperature, at the specified temperature, or 20 °C above the specified temperature.	
2. Test direction for tensile, Charpy and bend tests could refer to Annex C of AWS D20.1	

4 Survey

4.1 Initial Survey

The manufacturer should be audited by the attending Surveyor. The initial survey of additive manufacturing facilities for production should include:

- .1 Witness of the additive manufacturing process
- .2 Survey of manufacturing control for repeatability
- .3 Evaluation of the quality management system
- .4 Document control for the manufacturing procedure, specification and quality control for sampling, testing, reporting
- .5 Incoming control for feedstock materials
- .6 Outgoing control for the AM build final parts or materials, etc.

4.2 Witness of Approval Tests

The approval tests should be witnessed by the attending Surveyor.

4.3 Annual Verification

The annual verification should be carried out by the attending Surveyor. The annual verification should include a plan to demonstrate the essential parameters are followed. During the annual verification, full or partial approval tests could be requested based on the performance of the annual production record.

5 Information to be Submitted for Approval by the Register

The following documents in Table 9.41 should be submitted for AM facility approval, for review and survey by the Register:

Table 9.41
Information to be Submitted for Additive Manufacturer Approval

No.	DOCUMENTATION ITEMS
1.	Quality management system
2.	Additive manufacturing capability
3.	Machine and operator qualification record, if requested by the <i>Register</i>
4.	Build volume model or test plan for standard qualification build
5.	Feedstock procurement specification and data sheet with testing results
6.	AM procedure specification including pre-build, build, and post-build
7.	Procedure specification qualification records linked to the material grade
8.	Destructive and non-destructive testing standard and testing report
9.	Material specification for final delivered condition

6 Range of Approval

The range of approval for the AM facility/manufacturer should be the combination of the following qualified specifications including any revisions.

- a) Machine
- b) Feedstock material approved or qualified in accordance with Annex 1
- c) AM procedure specification including pre-build, build, and post-build
- d) Materials specification of final delivered condition
- e) Supplementary tests can be carried out and recorded to expand the range of approval. Requalification should be carried out if there is any quality concern for the delivered AM part or material.

Notes:

- .1 For AM Level 1, 2 and 3, all test results should meet the minimum design requirements.
- .2 Unless otherwise agreed, powder and wire feedstock should be type approved in accordance with Annex 1. The manufacturer can procure approved feedstock from different approved suppliers/brands. The approved feedstock type and grade should be documented for each specific supplier.
- .3 Unless otherwise agreed, the approval tests in Annex 2 should be carried out for Approval for Manufacturer.
- .4 For AM Level 2 and 3, each material grade should be qualified and approved. For AM Level 1, a family of materials may be qualified and approved with the support of a risk analysis and/or physics simulation, which could be specially considered and agreed to by the *Register*. The material group could be categorized to:
 - A: Unalloyed, low-alloyed steels and high alloyed ferritic steels
 - B: Austenitic, martensitic and precipitation hardening steels
 - C: Titanium and Titanium alloys, Niobium, Zirconium and other reactive materials
 - D: Aluminum alloys
 - E: Magnesium alloys
 - F: Nickel alloys, Cobalt alloys
 - G: Other than above, such as Copper alloys, Ceramic
- .5 The post-build heat treatment condition should be recorded during the qualification and the same heat treatment condition should be followed during production. Typical heat treatment conditions for AM final parts/materials include:
 - A: As build
 - SR: Stress Relief
 - SA: Solution Annealed
 - HIP: Hot Isostatic Pressed
 - Other: Other Delivery Conditions

ANNEX 3: APPROVAL FOR ADDITIVE MANUFACTURING REPAIR FACILITY

1 General

Annex 3 is to apply the additive manufacturing process to repair damaged parts back to the approved design.

If the parts are class items, the repair facility or repair process should be approved by the *Register*. If the parts are not class items, the repair process should be qualified by the repair facility and the repair facility may be recognized by the purchaser or approved by the *Register*.

Approval for a repair facility involves a documentation review, an audit of the facility and the witness of approval tests. Unless otherwise agreed, the approval is valid for a maximum of 5 years subject to annual verification and/or endorsement by the attending Surveyor. An additional audit may be requested.

2 Approval Application

Approval should be requested by the client, along with supporting information and a detailed inspection and test plan (ITP), refer to Table 9.42.

Table 9.42
Approval Application for Additive Manufacturing Repair Facility

No.	ITEM
1.	An outline description of the repair facility including the quality management system, a facility description, details of the organization and quality control responsibilities
2.	Additive manufacturing repair capability
3.	Programme of inspection and evaluation of damaged parts prior to repair
4.	A list of documented repair facility's repair procedures, specifications, documentation and reports and any historical repair certificates or data
5.	Documented inspection and testing plan for parts after repair for both qualification and production

3 Repair Procedure Specification and Qualification

3.1 General

The additive manufacturing procedure specification for repair should be prepared for each material and each part. Prior to conducting the repair procedure qualification tests, the repair procedure should be submitted and approved by the *Register*.

3.2 Repair Procedure Specification Approval

The repair procedure specification should be submitted to the *Register* for review and approval. A general description of the procedure should be prepared in accordance with subsection 5.3 and 5.5.

3.3 Approval Tests

Test coupons should represent the shape of the intended parts such as flat or cylinder test coupons, and the specific form of repair as allowed by the application standard for the intended use.

Refer to Table 9.43, test coupons should be sufficient to complete the required approval tests. Based on the design requirements, the repair facility should select the applicable tests in Table 9.44. Test methods and test results should be in accordance with Table 9.45.

Unless otherwise agreed, the following approval tests in Table 9.43 should be carried out and test results should be reported in accordance with subsection 7.3 for inspection and testing and included in the qualification records.

Table 9.43
Documentation for Approval Tests and Test Results

TYPES OF TESTS	RECORDED ITEMS IN TEST RESULTS
Visual inspection:	Sample ID and results
Dimension inspection:	Sample ID and results
Surface flaw inspection:	Sample ID and results
Embedded flaw inspection (if required):	Sample ID and results
3 tensile tests for interface cross- section (if required and applicable to the damage):	Sample ID, sample orientation, sample size and test results including yield strength, tension strength, failure type and location
1 set of Charpy impact test for interface cross-section, applicable to materials with ductile-to-brittle transition (if required and applicable to the damage):	Sample ID, sample orientation, sample size and test results
Bend tests for wire arc DED processes (if applicable):	2 in the Z and 2 in X/Y direction
Hardness test for interface cross- section and heat affected zone (HAZ) in substrate:	Sample ID, hardness values or hardness profile from AM build material to HAZ
Microstructure and macrostructure examination (if required):	Sample ID, part thickness at the section plane, section plane angle relative to build platform, magnification, and results
Chemical analysis:	Sample ID, and results

Table 9.44
Approval Tests for Additive Manufacturing Repair Process

MATERIAL	TEST ITEMS (AS LISTED IN TABLE 9.45)
Structural Steels	(1) (2) (3) (4) (5)
Nonferrous Metals for Structural Use	(1) (2) (3) (4) (5)
Corrosion Resistant Layer	(2) (4) (6) (7)
Wear-resisting Layer	(1) (3) (4) (5) (7)
Other material or other application	According

PART 25

AMENDMENTS No. 1

Table 9.45
Test methods

TEST TYPE		SAMPLING AND TEST PROCESS	ACCEPTANCE CRITERIA FOR TEST RESULTS
1)	Tensile Test (Room and High Temperature)	Refer to Rules or relevant internationally or nationally recognized standards and this Annex 3/3.3	The minimum tensile strength should meet the design technical requirements and not to be lower than the base metal value
2)	Bending Test		The bent surface of the specimen is not to reveal any crack exceeding 3 mm
3)	Impact Test		Meet the base metal requirements, or design technical requirements
4)	Hardness Test		The repair layer is to meet the design technical requirements, and the heat affected zone and base metal are to meet the recognized standards
5)	Macro Section Test		Well fused, no defect
6)	Corrosion test, if required		Meet the design technical requirements
7)	Chemical Composition		Meet the design technical requirements
8)	Microstructure		Meet the design technical requirements
9)	Fatigue Test, if required		Meet the design technical requirements

4 Survey

4.1 Initial Survey

The manufacturer should be audited by the attending Surveyor. The initial survey of additive manufacturing repair facilities should include:

- Witness of the additive manufacturing repair process
- Survey of repair control for agreed repeatability
- Evaluation of the quality management system, document control for repair procedure, specification and quality control for sampling, testing, reporting
- Incoming control for feedstock
- Inspection and testing procedure of damaged traditionally manufactured parts
- Outgoing inspection and testing procedure for the final repair parts through AM process, etc.

4.2 Witness of Approval Tests

The approval tests should be witnessed by the attending Surveyor.

4.3 Annual Survey

The annual survey should be carried out by the attending Surveyor. The annual survey should include a plan to demonstrate the essential parameters are followed by production of a test coupon. During the annual survey, full or partial approval tests could be requested based on the performance of the annual production/repair record.

5 Information to be Submitted for Approval by the Register

The following items in Table 9.46 should be submitted to the Register:

Table 9.46
Information to be Submitted for Additive Manufacturing Repair Facility Approval

No.	DOCUMENTATION ITEMS
1.	Documentation of the damaged part including the original dimensions and material grade for substrate, allowed wastage, method of defect excavation and verification of defect removal.
2.	Audit report for the repair facility by the Class Society
3.	Operator qualifications record
4.	AM build material specification and documentation
5.	AM repair procedure specification
6.	Types of approval tests, test standards and test results in Annex 3/3.3
7.	Surveyor's report of the witness of the repair procedure qualification approval tests
8.	Qualification records with a certifying statement acknowledging the validity of the data and certifying the qualification tests and test results

6 Range of Approval

For repair of a damaged metallic part, a repair procedure specific approval letter should be issued to the repair facility by the Register, refer to Table 9.47.

Table 9.47
Information to be Submitted for Additive Manufacturing Repair Facility Approval

No.	ITEMS TO BE INCLUDED IN APPROVAL LETTER
1.	Qualified feedstock linked to feedstock supplier
2.	Qualified procedure(s) for repair
3.	Compatible substrate material grade(s)
4.	Applicable range of part size or section thickness

In addition, the approved AM repair procedure may be applied to other application scopes provided supplementary tests are carried out to expand the range of approval.