



2020

Guidelines for Additive Manufacturing Approval & Inspection

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APPLICATION OF
"Guidelines for Additive Manufacturing Approval & Inspection"

1. This guideline provides procedures for approval and inspecting metal products manufactured using additive manufacturing technology known as "3D printing".
2. Since the products made by additive manufacturing technology can be various, the relevant regulation can be adjusted to the characteristics of the product that is applied for approval. So refer to this guideline for inspection and approval procedures.

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CHAPTER 1 GENERAL

Section 1 General

101. Application

1. This guideline provides procedures and methods that can be applied to type approval of feedstock, approval of manufacturing process, product inspection, etc. for metal equipment on a ship manufactured by additive manufacturing (3D printing) technology.
 - (1) The scope of this Guideline is the additive manufacturing using Laser Metal Deposition(LMD) method, Laser Powder Bed Fusion(LPBF) method and Wire Arc Additive Manufacturing(WAAM) method.
 - (2) The feedstock type are limited to wire and powder.
 - (3) In case other additive manufacturing method and feedstock of (1) and (2) are to be used, it is to be agreed with the Society.
2. The matters not specified in this Guideline are subject to the respective requirements of the Rules and Guidance for the Classification of Steel Ships and **the Guidance for Approval of Manufacturing Process and Type Approval, Etc..**
3. In addition, the matters not provided for in the Rules and Guidance for the Classification of Steel Ships and of the Guidance for Approval of Manufacturing Process and Type Approval are to be approved by the Society and may comply with the relevant National or International standards.
4. The additive manufacturing (3D printing) technique in this guideline does not apply to repair work.
5. If it is impracticable to apply the requirements specified in this Guideline, alternative methods are to be discussed by the Society.

102. Definition of Terms

1. The definitions of terms used in this Guideline are as follows. The definitions of terms are to be in accordance with the Rules and Guidance for Steel Ships unless otherwise specified in this Guidance.
 - (1) 3D printer : a machine used for 3D printing
 - (2) 3D printing : the fabrication of objects through the deposition of a material using a print head, nozzle, or other printer technologies
 - (3) Additive Manufacturing(AM) : a process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methods and forming manufacturing
 - (4) Additive Manufacturing system(AM system) : software and machinery for Additive Manufacturing
 - (5) Additive Manufacturing machine(AM machine) : the hardware, machine control software, setup software, and peripherals required to complete the manufacturing cycle as part of the additive manufacturing system
 - (6) Feedstock : bulk raw material supplied to the AM process; generally supplied in various forms such as liquid, powder, suspension, wire, filament, sheet, etc. This guideline mainly deals with feedstock of powder type and wire type.
 - (7) Post processing : one or more process steps taken after the completion of an additive manufacturing build cycle in order to achieve the desired properties in the final product
 - (8) Powder batch : as a feedstock, reusable and unusable powder or a mixture of both powder. The powder batch can be used in one or more production using different process parameters.
 - (9) Powder bed : the manufacturing zone within the additive manufacturing system where the powder feedstock is melted or selectively fused by thermal energy to produce an output
 - (10) Process parameters : set of operating parameters and system settings used during a build cycle
 - (11) AM file format : file format for communicating AM model data including a description of the 3D surface geometry with native support for color, materials, lattices, textures, constellations and metadata
 - (12) Directed Energy Deposition, DED : additive manufacturing process in which focused energy is

used to fuse materials by melting as they are being deposited. The focused thermal energy means a focused energy source (eg laser, electron beam or plasma arc) that melts the material to be deposited.

- (13) Laser Metal Deposition, LMD : an AM process in which lasers are used to fuse feedstock by melting as they are being deposited
- (14) Laser Powder Bed Fusion, LPBF : an AM process that uses a laser to sinter or melt powder particles in the powder bed for making the desired shape
- (17) Wire Arc Additive Manufacturing, WAAM : an AM process that manufactures 3D structure by melting wire using arc source similar to the conventional welding process

2. The classification of additive manufacturing techniques covered in this Guidance is shown in **Figure 1.1** and the principle of each additive manufacturing techniques is shown in **Figure 1.2**.

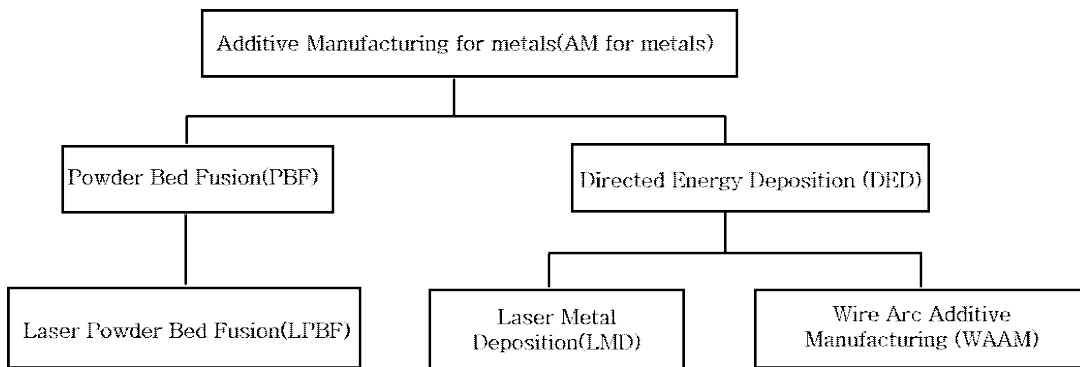


Fig 1.1 The classification of additive manufacturing techniques

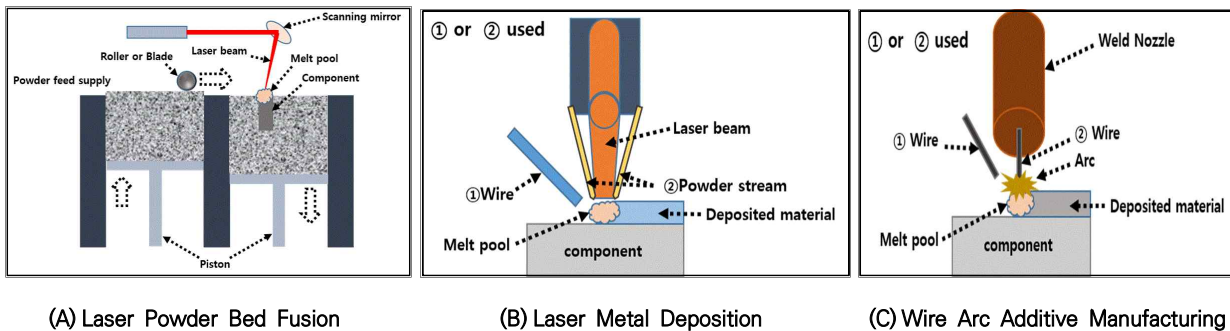


Fig 1.2 The principle of additive manufacturing techniques

Section 2 Approval Procedure

201. Approval procedure

1. The approval procedure for the additive manufacturing is to be in accordance with **Fig 1.3**.

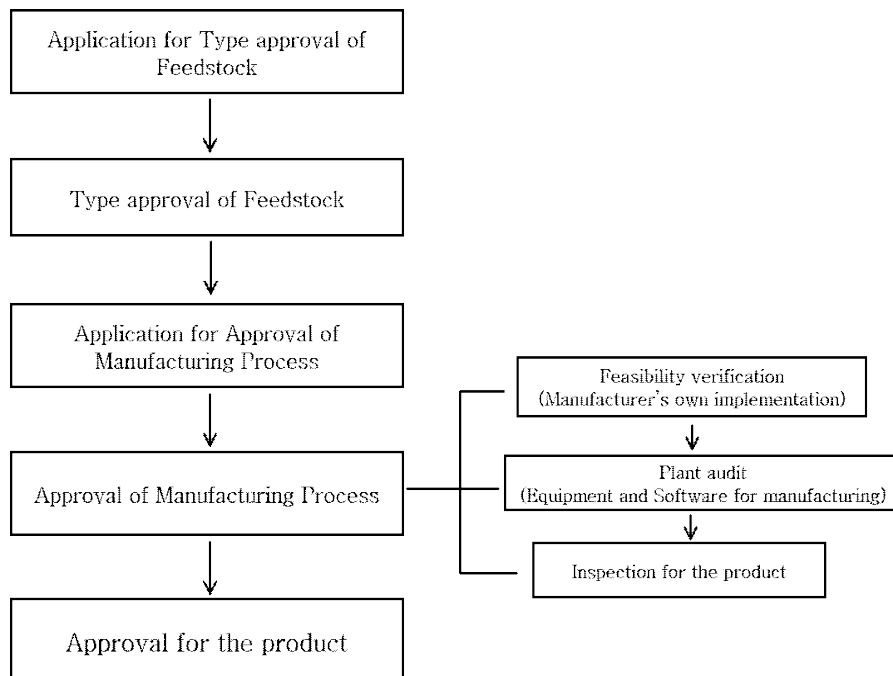


Fig 1.3 Approval procedure for the additive manufacturing



CHAPTER 2 TYPE APPROVAL OF FEEDSTOCK

Section 1 General

101. General

1. Application

This requirements of this Chapter apply to approval procedure and tests for Type Approval of feedstock.

2. Approval range

Approval of the manufacturing process may be omitted for additive manufacturing of the product having the same structure under approved size range and approved by the Society.

102. Approval application

1. The applicant

The applicant is, in principle, to be the manufacturer of the materials. However, the applicant, where deemed appropriate by the Society, need not always be the manufacturer of the materials.

2. The manufacturer wishing to obtain a type approval is to submit a copy of the application of type approval (refer to **Annex 6 of the Guidance for Approval of Manufacturing Process and Type Approval, Etc.**) of the Society, together with three copies of the required data for approval and two copies of the required data for reference, to the Society.

3. Data to be submitted

(1) Data for approval

The following reference data are to be submitted to the Society. Where test methods and procedure are specified into this **Guideline, KS, ISO** standard, etc., the relevant standards may be indicated and replaced.

(A) Type test program

(a) Material grade

(b) Sample's manufacturing method (Type of Feedstock, manufacturing, equipment for manufacturing, delivery condition and post processing)

(c) Dimension and weight of samples

(d) The location and direction of specimens

(e) Test items, test method and Acceptance criteria

(d) Location for test (When conducting out of plant)

(B) Applicable standard, codes or the Rules relevant to (A), if applicable

(C) Applied additive manufacturing technique (LPBF, LMD, WAAM, etc.) and various parameters for each technique

(D) Handling and storage method

(E) Recommendations on reuse (recycling) of feedstock

(F) Environmental, safety and human matters

(G) In the case of wire, requirements specified in **Chapter 3, Section 2, 202. of the Guidance for Approval of Manufacturing Process and Type Approval, Etc.**

(H) Powder

(a) Chemical composition (including crystalline phase and test method)

(b) Thermal characteristics (melting temperature)

(c) Particle size and distribution information

(d) Density

(e) Powder flow characteristics (using hall flowmeter according to **ISO 4490**)

(f) Description of Particle shape and morphology (**ISO 9276-6**)

(g) Oxygen content

(2) Data for reference

In addition to the **Ch 3, Sec 1, 102. of the Guidance for Approval of Manufacturing Process and Type Approval, Etc.**, the following data is to be submitted.

- (A) Performance used for purposes other than additive manufacturing (welding, etc.)
- (B) Performance approved or applied by industries other than ship and offshore

Section 2 Type test

201. Type test

1. General

- (1) The properties of feedstock (mechanical properties, material types, etc.) are to be met the requirements of additive manufacturing machines and end users.
- (2) Additives, such as intentionally added pigments, can affect the properties of feedstock, so re-testing is required if changed.
- (3) The type test can be conducted by feedstock manufacturer or by an organization designated by the manufacturer / the Society, and inspected by the Surveyor.
- (4) Type tests are required for each feedstocks and material type. In addition, type tests are required for each additive position.
- (5) Additional tests may be required by the Surveyor as deemed necessary.

2. Specimen

- (1) The manufacturer selects the shape (cylindrical, rectangular, etc.) of the samples so that the required test specimens can be sufficiently collected, and manufactures two samples with different shapes. The additive directions are to be recorded.
- (2) Unless otherwise specified, the specimen is taken at 1/4 of the sample's thickness.
- (3) Only the heat treatment recommended by the feedstock manufacturer or required by the additive manufacturing manufacturer can be applied to the samples. After all hest treatment, the specimen can be taken.
- (4) An appropriate non-destructive test is to be carried out on the samples before the specimen is taken.
- (5) The shape of the specimen is in accordance with **Part 2** of the Rules.

3. Approval test and acceptance criteria

- (1) Test items and acceptance criteria are to be as given in **Table 2.1**.

Table 2.1 Approval test and acceptance criteria

| Approval test items ⁽¹⁾ | Testing method and specimen selection ⁽²⁾ | Acceptance criteria |
|---|---|---|
| Visual inspection | All surfaces of sample are inspected, and no machining is performed. | In accordance with the Classification Technical Rules , International / National standards recognized by the Society or manufacturer specifications approved by the Society. |
| Chemical analyses | Intentionally added elements or residual elements, including major chemical components are to be analyzed. Chemical components analyzed in feedstock and sample are compared with each other. | |
| Density | The apparent density including the pores and the tap density are measured. It is carried out according to ASTM B417 and ASTM B527 , respectively. | |
| Tensile test | For each sample, two specimens are taken in each direction (x, y, z). | |
| V-notch Charpy impact test | For each sample, 2 sets (3 specimens in 1 set) are taken in each direction (x, y, z), and the test temperature is as follows. - 20 °C - For materials with low temperature properties, the temperature required by Pt 2 of the Rules | |
| Bend test | For each sample, two specimens are taken in each direction (x, y, z). The bending angle is 180 degrees. | |
| Micro structure | Microscopic photographs (100x, 500x) are to be taken. | |
| Corrosion resistance test | It is performed when corrosion resistance is required, such as stainless steel. | |
| Hydrogen test ⁽³⁾ | In accordance with Pt 2, Ch 2, Sec 6, 602. 6 of the Rules. | |
| Test for powder re-use | In order to know how many times the powder can be reused, a comparative test of reused powder is conducted with the powder that is not reused. The test method is given by the manufacturer. | |
| Non-destructive test | Considering the type and shape of sample, NDT method that can identify defects on the internal and surface is selected. | |
| Particle morphology for powder | Particle morphology for powder is measured according to ASTM F3049 . | |
| (Notes) | | |
| (1) If necessary, tests may be added. | | |
| (2) If accepted by the Society, the test may be carried out in the method suggested by the manufacturer, unlike this Table. | | |
| (3) It is carried out in the case of a low hydrogen type. | | |

202. Marking

The marks of feedstock that accepted the test is as follows.

- (1) Additive manufacturing techniques used for each type of feedstock and material grades are added together.
- (2) It is followed examples as below.
 - (A) AMF(Additive Manufacturing Feedstock)-P(Powder)-LPBF(Laser Powder Bed Fusion)
-16Cr5Ni(Stainless steel casting for propeller) : **AMF-P-LPBF-16Cr5Ni**
 - (B) AMF(Additive Manufacturing Feedstock)-W(Wire)-LMD(Laser Metal Deposition)
-16Cr5Ni(Stainless steel casting for propeller) : **AMF-W-LMD-16Cr5Ni**

203. Periodical inspection

It is in accordance with **Ch 3, Sec 2, 204.** of **Guidance for Approval of Manufacturing Process and Type Approval, etc..** ↓

CHAPTER 3 APPROVAL OF MANUFACTURING PROCESS

Section 1 General

101. General

1. Application

The requirements of this Chapter apply to approval procedures and tests for the approval of manufacturing process of manufacturers who manufacture products using additive manufacturing technology.

102. Approval application

1. The manufacturer wishing to obtain the approval of manufacturing process is to submit a copy of the application of approval for manufacturing process (refer to **Annex 6 of the Guidance for Approval of Manufacturing Process and Type Approval, Etc.**) of the Society together with three copies of the required data for the approval and two copies of the required data for reference to the Society.

2. When applying for approval, the manufacturer should consider the product's approval range.

3. Data to be submitted

(1) Data for approval

The following reference data are to be submitted to the Society. Where test methods and procedure are specified into this **Guideline, KS, ISO** standard, etc., the relevant standards may be indicated and replaced.

- (A) Type of products (as described summary of products)
- (B) Manufacturing method
- (C) Range of applicable product size (dimension and weight)
- (D) Type of feedstock
- (E) Delivery conditions
- (F) Test plan for the approval of manufacturing process
 - (a) Material grade of samples
 - (b) Sample's manufacturing method (Type of Feedstock, manufacturing, equipment for manufacturing, heat treatment and post processing)
 - (c) Dimension and weight of samples
 - (d) The location and direction of specimens
 - (e) Test items, test method and Acceptance criteria
 - (f) Location for test (When conducting out of plant)
- (G) Applicable standard, codes or the Rules relevant to (F), if applicable
- (H) Other data required by the Society

(2) Data for reference

In addition to the **Ch 2, Sec 1, 102. of the Guidance for Approval of Manufacturing Process and Type Approval, Etc.**, the following data is to be submitted.

- (A) Manufacturer's feasibility verification data
- (B) Data for design
 - (a) Design Requirements (Legal and Regulatory Requirements)
 - (b) Design concept
 - (c) Component complexity
 - (d) Design optimization
 - (i) Prepared 3D Model Information
 - (ii) Procedures for reviewing the quality of the 3D model and suitability for AM (e.g. inner surfaces, overhanging features)
 - (iii) Details about scaling, slicing, sub-division, hatch strategies, simulation models, and boundary conditions
 - (iv) Information on how to place a product that is fabricated in the optimal direction by adding fixtures, supports or other required shapes (see **ISO/ASTM 52921** for build orientation)
 - (v) Information for integration of topology optimization with design for additive tools,

- lattice structures, geometric compensation approaches, optimization of input file, slicing and build orientation for achieving part tolerances (minimizing and optimal removal of support structures)
- (vi) Model calculation of distorted geometry result performed in advance
- (e) Final design
- (C) Data relating to facilities
- (a) Facility descriptions, ambient conditions (and control) and other related information
 - (b) Specifications, functions and limitations of additive manufacturing systems (e.g. model number, software and firmware version)
 - (c) Parameter setting of AM machine and variable parameters that operator can control
 - (d) Details of accreditation of AM machine
 - (e) Operator qualification
 - (f) Details of data sensing and logging procedures to input file version verification, trace file revisions and machine logging
 - (g) Identification ensuring full traceability
 - (h) Generating reports on control data
 - (i) AM machine preparation and raw material verification
 - (j) Loading and retrieval of build data
 - (k) Optimal process variables (laser power, scan speed, height and gap of layer, respectively height and width, overlap rate building direction, printing strategy including number and spacing of parts, etc.) and their control range
 - (l) Scan and deposition strategies and monitoring methods
 - (m) Sieving type and mesh size
 - (n) Details of gases used during the process, flow rate
 - (o) Preheating of feedstock
- (D) Data relating to software
- (a) Details of STL/AMF files and preprocessing software used
 - (b) Procedures for quality check of STL/AMF files (e.g. magic software)
 - (c) Details of the software version and IP rights for the design to be printed
 - (d) Methods for data encryption, compression, and other cyber security issues
- (E) Data relating to manufacturing process
- (a) Standard for operating procedures
 - (b) Work instructions for each part/component
 - (c) Risk assessment
 - (d) Test procedures on site
 - (e) Instructions for Installation, operation and maintenance
 - (f) Pre-maintenance items
 - (g) Performance test items
 - (h) Calibration data
 - (i) Manufacturing parameters
- (F) The following data are to be additionally submitted depending on the type of techniques.
- (a) Laser Powder Bed Fusion
 - (i) Laser (e.g. power, spot dimensions, exposure time, focus position)
 - (ii) Scanning strategy (e.g. scan speed, layer thickness)
 - (iii) Point distance (distance between successive laser spots)
 - (iv) Hatch distances and conditions (shift between tracks in the plane of the beam scanning and track distance)
 - (v) Laser absorptivity or reflectance (e.g. substrate material may require shot blasting to reduce reflectance)
 - (vi) Build environmental controls (e.g. inert gas, build platform preheating temperature, build space temperature and pressure, recoater blades);
 - (vii) External environmental controls (e.g. temperature, humidity)
 - (viii) Powder feedstock (e.g. particle size range and distribution, morphology)
 - (ix) Baseplate control (e.g. selected baseplate material for build, cleanliness of the baseplate)
 - (b) Laser Metal Deposition
 - (i) Laser (e.g. power, spot dimensions)
 - (ii) Nozzles (coaxial, three-beam or side feeder)
 - (iii) Travel speed
 - (iv) Standoff distance (distance between nozzle tip and surface)

- (v) Shielding gas (e.g. Ar or He, gas flow rate and direction)
 - (vi) Heat input and cooling characteristics
 - (vii) External environmental controls (e.g. temperature, humidity)
 - (viii) Powder feedstock (particle size range and distribution, morphology, feed rate, flow rate, deposition rate)
 - (ix) Laser absorption/reflectance (e.g. substrate material may require shot blasting to reduce reflectance)
 - (x) Baseplate control (e.g. selected baseplate material for build, cleanliness of the baseplate)
- (c) Wire Arc Additive Manufacturing
- (i) Consumables manufacturing information
 - (ii) WAAM procedures and positions
 - (iii) Technical details (e.g. weaving, multi-wire)
 - (iv) Consumables, including flux and shielding gas
 - (v) Consumables control (e.g. drying conditions)
 - (vi) Chemical composition of the deposit
 - (vii) Process parameters
 - (viii) Preheating and Interpass Temperature
 - (ix) Cleaning between layers and inspection during production
 - (x) Baseplate control (e.g. selected baseplate material for build, cleanliness of the baseplate)
 - (xi) Post heat treatment
- (d) Post processing
- (i) Waiting time for the object on the machine platform after finishing the additive work
 - (ii) Machining or other surface finishing work
 - (iii) Methods for taking out the object from the machine's platform
 - (iv) Removal of powder particles from the inner hollow part
 - (v) Object cleaning
 - (vi) Methods for removal of support from the product
 - (vii) Details of post heat treatment
 - (viii) Machining or other surface finishing work, such as treatment with abrasive media or shot peening, and related requirements
 - (ix) Density achieved, as well as methods how this is verified
 - (x) Process for cleaning the AM machine after printing
 - (xi) Heat treatment method for stress relief

103. Approval range

1. The approval test is required for each product and feedstock.
2. The approval range for the size of each product is in accordance with the relevant **Classification Technical Rules**.
3. The approval test is required for each AM machine including the 3D printer.

104. Data review

The Society examines the approval test program for approval of manufacturing process submitted in accordance with the requirements in **102. 3** and where deemed appropriate, the test program is approved and returned to the manufacturer.

105. Type approval of feedstock

1. The AM manufacturer apply to AM process based on various parameters used in type approval of feedstock.
2. If there is no type approval for feedstock, the approval of manufacturing process can be performed by submitting the following data on feedstock.
 - (1) Powder
 - (A) Powder supplier information
 - (B) Packing date

- (C) The identification information of the powder (batch number)
- (D) Product description (product name, grade)
- (E) Powder manufacturing process
- (F) Instructions for packing and storage (maximum oxygen content information)
- (G) Material Safety Data Sheets (MSDS)
- (H) Powder Recycling or Reuse Information
- (2) Wire (Solid consumables)
 - (A) Wire supplier information
 - (B) Packing date
 - (C) The identification information of the wire (batch number)
 - (D) Product description (product name, grade, diameter, weight and spool size)
 - (E) Instructions for packing and storage
 - (F) Material Safety Data Sheets (MSDS)
 - (G) Chemical composition
- (3) For powder, test samples are to be taken from the powder batch to verify material information on the following items: Sampling procedures are in accordance with **ISO 3954** or equivalent standards.
 - (A) Chemical composition (including crystalline phase and test method)
 - (B) Thermal characteristics (melting temperature)
 - (C) Particle size and distribution information
 - (D) Density
 - (E) Powder flow characteristics (using hall flowmeter according to **ISO 4490**)
 - (F) Description of Particle shape and morphology (**ISO 9276-6**)
 - (G) Oxygen content

106. Feedstock

1. Storage of feedstock

- (1) Feedstock is to be stored by separating and labelling for each type, and humidity is to be controlled in designated storage areas.
- (2) Powder feedstock is not to be mixed with different types or batches during transportation or storage.
- (3) A system is to be settled to clearly manage the distinction between used and reused feedstock.

2. Reuse of powder

- (1) When reusing feedstock, obstructions are not to be mixed and to be filtered out by proper facilities.
- (2) The manufacturer should identify how many times the feedstock is reused. For identifying, the manufacturer should test whether the reused feedstock has a quality equivalent that of the un-reused feedstock and submit the result. The number of reuses identified in the type approval of feedstock can be accepted.

Section 2 Feasibility verification

201. General

- 1. The applicant is to submit the feasibility verification data for reference when applying for approval of the manufacturing process of the product using additive manufacturing technology.
- 2. It is possible to determine whether the product is an equipment (component) that can be used for ship through feasibility verification.

202. Feasibility verification data

- 1. Feasibility verification data includes as follows.

(1) Risk assessment data

- (A) High risk stages that may occur in the production process are to be identified, and control method for identified factors is to be established.
- (B) Sensitivity according to the shape and material of the product is to be identified, and a

- management plan is to be established.
- (2) Pre-test information and results of prototypes (pre-produced)
 - (3) Applicable Rules, international/national standards, and specification
 - (4) Deviation of acceptance criteria from relevant Rules (if applicable)
 - (5) Procedures related to design, manufacturing, testing and inspection

Section 3 Plant audit

301. Plant audit

1. Purpose

The Society will, where deemed appropriate upon review of documents and data submitted, carry out the plant audit in the presence of the Surveyor to verify that the manufacturer has a technical capability to continuously produce the proposed products of equal level in quality under the stable workmanship to the satisfaction of the Society.

2. Items to be audited

The plant audit is to apply to the following items for each manufacturing plant and each product.

- (1) Quality system in general
 - (A) Establishment and implementation of quality system
 - (B) Observance and establishment of procedure for handling of customer complaints
 - (C) Education and training of employees
- (2) Control of process and quality
 - (A) Observance of work instruction
 - (B) Observance and confirmation of Q.C flow charts
 - (C) Control of nonconforming product and corrective action
 - (D) Feedstock management
- (3) Control of manufacturing and inspection equipment
 - (A) Observance and establishment of maintenance procedure for manufacturing equipment and software
 - (B) Calibration and control of inspection equipment
- (4) Others
 - (A) Updating of documents such as applicable standards, etc.
 - (B) Comprehension of related requirements for class surveys
- (5) Audit methods and acceptance criteria are to be as deemed appropriate by the Society.

3. Time for audit

The time of the audit is to correspond, in principle, to either the time when the proposed product is manufactured or the time when the approval test is carried out. In this case, the manufacturer is to provide the necessary information related to this audit.

4. Exemption of audit

When the manufacturer submits the application of newly produced product with the same manufacturing facilities and similar method of manufacture for products which have been approved by the Society, the audit items may be exempted wholly or partly according to the review result of the documents.

Section 4 Approval test

401. Approval test

1. General

- (1) Test method and acceptance criteria are to be submitted before approval test.
- (2) The number, direction, and location of the specimens are to be discussed in advance with Surveyor.

2. Samples

- (1) The sample(product) is to be represented the approval range considering follows.
 - Material type or grade
 - Manufacturing process
 - Type and manufacturer of feedstock
 - Types and brand of facilities
 - Product type or shape
 - Maximum size or weight
 - Heat treatment or post processing
- (2) One sample(product) with the maximum size and one with the average size are to be manufactured separately. If only products of the same size are produced, two products are to be manufactured for sample.
- (3) Selection of test samples and approval tests, in principle, are to be carried out in the presence of the Surveyor. However density, micro structure, corrosion resistance, fatigue, residual stress or in case the Society deems the test unnecessary may be omitted.
- (4) When the sample (product) has a shape and dimensions that are difficult to be taken all of the required specimens, it can be added layers to the insufficient direction (x, y, z).
- (5) The specimens are to be taken after the final conditions including heat treatment and surface treatment of the product are completed.

3. Test items and specimen selection

In principle, the test items are to be in accordance with **Table 3.1** below, and the general requirements for the application field of the product for which approval is applied should be considered, and approved before approval test.

Table 3.1 Test item and specimen selection

| Approval test items ⁽¹⁾ | Testing method and specimen selection ⁽²⁾ | Acceptance criteria |
|--|--|---|
| Chemical analyses | Intentionally added elements or residual elements, including major chemical components are to be analyzed. | In accordance with the Classification Technical Rules , International / National Standards recognized by the Society or manufacturer specifications approved by the Society. |
| Density | It is carried out according to ISO 3369 or equivalent standards. | |
| Tensile test | For each sample, two specimens are taken in each direction (x, y, z). | |
| V - n o t c h Charpy impact test | For each sample, 2 sets (3 specimens in 1 set) are taken in each direction (x, y, z), and the test temperature is as follows. - 20 °C - Design temperature or the temperature required by relevant Rules | |
| Bend test | If required, two specimens are taken in each direction (x, y, z). | |
| Micro structure | Microscopic photographs (100x, 500x) are to be taken. | |
| Macro structure | It is carried out according to ISO 4969 or equivalent standards. | |
| Corrosion resistance test | It is performed when corrosion resistance is required, such as stainless steel. | |
| Fatigue test ⁽³⁾ | Proceed if required. | |
| R e s i d u a l stress ⁽³⁾ | Proceed if required. | |
| Non-destructive test | Considering the type and shape of sample, NDT method that can identify defects on the internal and surface is selected. | |
| Welding test | Proceed if required. | |
| (Notes) (1) If necessary, tests may be added. (2) The location of specimen is in accordance with the Classification Technical Rules related to the product, and the manufacturer can suggest it unless otherwise specified. (3) If there is an appropriate test report, such as a manufacturer's report, this test may be omitted. | | |



CHAPTER 4 PRODUCT

Section 1 General

101. General

1. The provisions of this Chapter apply to approval procedures and tests for inspection of products using additive manufacturing techniques.

Section 2 Test and inspection

201. General

1. The test procedure and acceptance criteria for individual products are in accordance with the **Classification Technical Rules** or equivalent International/National Standards relevant to the products, and the approval test is carried out in the presence of the Surveyor.
2. The manufacturer should inform to the Surveyor about the Specifications with the customer that can affect the mechanical properties and quality of the product, and discuss the inspection method and acceptance criteria before test.
3. The Surveyor may require additional tests because AM is new technique.

202. Test method

1. Test and inspection plan

- (1) The test and inspection plan based on the approval of manufacturing process are to be submitted to the Surveyor
- (2) The test and inspection plan are to be described for identifying the different parts with the approval of manufacturing process.
- (3) Classification Technical Rules or equivalent International/National standards relevant to the test methods and acceptance are to be provided.
- (4) The manufacturer may propose items not specified in the **Classification Technical Rules** or international / national standards considered equivalent.
- (5) Test and inspection can be carried out after the submitted test and inspection plan have been satisfied by the Surveyor.

2. Samples

- (1) The number of samples are to be in accordance with the **Classification Technical Rules** or equivalent International/National standards relevant to products. The samples(product) are to be represented the shape of the products and have the maximum and average size of the products.
- (2) If it is determined that the product is special, additional sample may be produced for test.
- (3) Considering the quantity of products produced, the number of samples may be increased/decreased appropriately after approval by the Society.
- (4) When the samples(product) has a shape and dimensions that are difficult to take all specimens, it can be laminated to the product by adding it in the required direction(x, y, z).
- (5) The specimens are to be taken from samples after the final conditions including heat treatment and surface treatment of the samples have been completed.

3. Test method

- (1) Visual inspection
 - (A) Visual inspection is performed on all surfaces of all products.
 - (B) Product size/dimension, surface roughness, etc. are measured and compared with the design.
- (2) Non-destructive test
 - (A) Non-destructive test is to be in accordance with the test and inspection plan.
 - (B) After considering the material and shape of the production, non-destructive test method is to be selected for identifying the defects on the internal and surface.

(3) Mechanical test

Mechanical test is in accordance with the **Classification Technical Rules** or equivalent International/National standards relevant to the product.

203. Marking

For AM products which have satisfactorily complied with the required tests, "-AM" is to be suffixed to the product marking.



GUIDELINES FOR ADDITIVE MANUFACTURING APPROVAL & INSPECTION

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