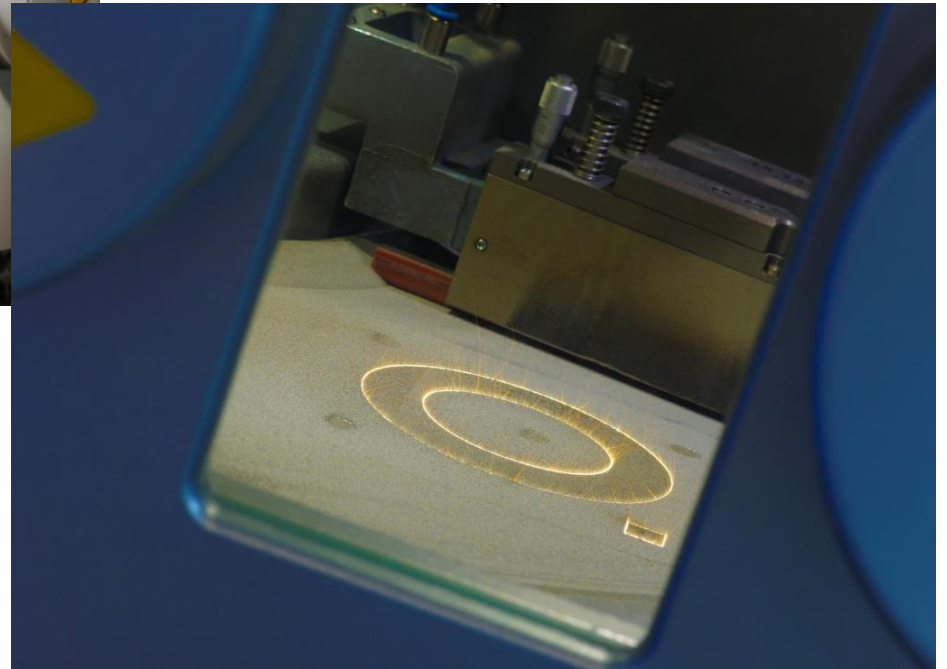




Casting Factors (CS 25.621) an approach to Additive Layer Manufacturing

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Certification Requirements for Materials



- CS 25.603 – Materials
- CS 25.605 – Fabrication
- CS 25.613 – Material Design Values
- CS 25.619 – Special Factors
- CS 25.621 – Casting Factors

CS 25.603 Materials

The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must –

- a) Be established on the basis of experience or tests;
- b) Conform to approved specifications, that ensure their having the strength and other properties assumed in the design data

CS 25.605 Fabrication methods

- (a) The methods of fabrication used must produce a consistently sound structure. If a fabrication process requires close control to reach this objective, the process must be performed under an approved process specification.

- (b) Each new aircraft fabrication method must be substantiated by a test programme.

CS 25.613 Material strength properties and Material Design Values



- (a) Material strength properties must be based on enough tests of material meeting approved specifications to establish design values on a statistical basis.
- (b) Material design values must be chosen to minimise the probability of structural failures due to material variability.
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CS 25.619 Special factors

The factor of safety prescribed in CS 25.303 must be multiplied by the highest pertinent special factor of safety prescribed in CS 25.621 through CS 25.625 for each part of the structure whose strength is –

- (a) Uncertain.
- (b) Likely to deteriorate in service before normal replacement; or
- (c) Subject to appreciable variability because of uncertainties in manufacturing processes or inspection methods.

Where the Agency is not satisfied in a specific case that a special factor is the correct approach to ensuring the necessary integrity of the parts of the structure under service conditions, other appropriate measures must be taken.

Castings Requirements (Critical)



BCAR D3-10 Castings

Complex castings shall be subjected in the finished condition to procedure:-

Each of three castings selected at random from the first twenty castings passed by the casting constructor shall be shown by test to have proof and ultimate factors respectively of not less than –

- a) 0.8 and 1.33 for Mg or Al alloy;
- b) 0.8 and 1.15 for steel

times the ultimate factor (1.5) for the stressing condition for the part concerned.

FAR 25.621 Casting Factor

- (a) *General* The factors, tests, and inspections specified in paragraphs (b) through (d) of this section must be applied in addition to those necessary to establish foundry quality control. The inspections must meet approved specifications. Paragraphs (c) and (d) of this section apply to any structural castings
- (c) *Critical castings.* For each casting whose failure would preclude continued safe flight and landing of the airplane or result in serious injury to occupants, the following apply:
 - (1) Each critical casting must-
 - (i) Have a casting factor of not less than 1.25; and
 - (ii) Receive 100 percent inspection by visual, radiographic, and magnetic particle or penetrant inspection methods or approved equivalent nondestructive inspection methods.
 - (2) For each critical casting with a casting factor less than 1.50, three sample castings must be static tested and shown to meet-
 - (i) The strength requirements of § 25.305 at an ultimate load corresponding to a casting factor of 1.25; and
 - (ii) The deformation requirements of § 25.305 at a load of 1.15 times the limit load.
 - (3) Examples of these castings are structural attachment fittings, parts of flight control systems, control surface hinges and balance weight attachments, seat, berth, safety belt, and fuel and oil tank supports and attachments, and cabin pressure valves.



CS/FAR 25.621 - Current

(c) *Critical castings.*

Each casting whose failure could preclude continued safe flight and landing of the aeroplane or could result in serious injury to occupants is considered a critical casting. Each critical casting must have a factor associated with it for showing compliance with strength and deformation requirements, and must comply with the following criteria associated with that factor:

- (1) A casting factor of 1.0 or greater may be used, provided that:
 - (i) It is demonstrated, in the form of process qualification, proof of product, and process monitoring that, for each casting design and part number, the castings produced by each foundry and process combination have coefficients of variation of the material properties that are equivalent to those of wrought alloy products of similar composition.

AMC 25.621(c)(1) - Premium Castings

The AMC details an acceptable means for compliance with CS 25.621 for using a casting factor of 1.0 or greater for “critical” castings used in structural applications. A premium casting process is capable of producing castings with predictable properties, thus allowing a casting factor of 1.0 to be used for these components. Three major steps, required by CS 25.621(c)(1)(i), are essential in characterising a premium casting process:

- qualification of the process,
- proof of the product, and
- monitoring of the process.

Premium Casting Process

The objective of a premium casting process is to consistently produce castings with high quality and reliability. To this end, the casting process is one that is capable of consistently producing castings that include the following characteristics:

- Good dimensional tolerance
- Minimal distortion
-
- Minimal residual internal stress
- Consistent mechanical properties

The majority of casting defects can be detected, evaluated, and quantified by various means. However, a number cannot. Thus, to ensure an acceptable quality of product, the significant and critical process variables must be identified and adequately controlled.

Qualification of Casting Process

To prove a premium casting process, it should be submitted to a qualification program that is specific to a foundry/material combination. The qualification program should establish the following:

- (a) The capability of the casting process of producing a consistent quality of product for the specific material grade selected for the intended production component.
- (b) The mechanical properties for the material produced by the process have population coefficients of variation equivalent to that of wrought products of similar composition. In most cases, the coefficients of variation for tensile ultimate strength and tensile yield strength less than or equal to 3.5% and 4.0% respectively is adequate to demonstrate this equivalency of mechanical properties.
- (c) The casting process is capable of producing a casting with uniform properties throughout the casting or, if not uniform, with a distribution of material properties that can be predicted to an acceptable level of accuracy.
- (d) The (initial) material design data for the specified material are established.
- (e) The material and process specifications are clearly defined.

Proof of Product

Subsequent to the qualification of the process, the production castings should be subjected to a production-proving program.

The production-proving program should establish the following:

- (a) The design values developed during the process qualification program are valid (e.g., same statistical distribution) for the production casting.
- (b) The production castings have the same or less than the level of internal defects as the test castings produced during qualification.
- (c) The cast components have a predictable distribution of tensile properties.

Monitoring the Process.

The foundry should employ quality techniques to establish the significant/critical process variables which impact on the quality of the product. The foundry should show that these variables are controlled with positive corrective action throughout production.

Modifications to the Casting Design, Material, and Process.

Modifications					Verification Testing		
Case	Geometry	Material	Process	Foundry	Qualification of Process	Proof of Product	Tests per CS 25.621(c)(1)
1	yes	none	none	none	not necessary	yes	yes (b)
2	none	yes	none	none	yes (a)	yes	yes (b)
3	yes	yes	none	none	yes	yes	yes
4	none	none	yes	none	yes (a)	yes	yes (b)
5	none	none	none	yes	yes (a)	yes	yes (b)

(a) The program described in paragraph 4. of this AMC to qualify a new material, process, and foundry combination may not be necessary if the following 3 conditions exist for the new combination:

- (1) Sufficient data from relevant castings to show that the process is capable of producing a consistent quality of product, and that the quality is comparable to or better than the old combination.
- (2) Sufficient data from relevant castings to establish that the mechanical properties of the castings produced from the new combination have a similar or better statistical distribution than the old combination.
- (3) Clearly defined material and process specifications.

(b) The casting may be re-qualified by testing partial static test samples (with larger castings, re-qualification could be undertaken by a static test of the casting's critical region only).



Additive Layer Manufacturing

Process Qualification

Associated with, as a minimum, organisation (foundry), equipment and material.

Establishes:-

Material specification and process specification that is capable of producing a consistent product with a known property variability.

Base Design Values.

Proof of Product

Associated with a specific component design.

Establishes:-

The specific component manufactured by a qualified process conforms to the defined product variability.

Product Monitoring

The material specification and process specification must define all the critical process variables as well as the methods for control and monitoring.

Additive Layer Manufacturing

Additionally

Re-qualification requirements after modification of component design, material change, equipment change, organisation change, operator change.

Also there needs to be consideration of operator competency demonstration and control.

CS 25.619 Special factors

The factor of safety prescribed in CS 25.303 must be multiplied by the highest pertinent special factor of safety prescribed in CS 25.621 through CS 25.625 for each part of the structure whose strength is –

(a) Uncertain.

..... or

(c) Subject to appreciable variability because of uncertainties in manufacturing processes or inspection methods.

Where the Agency is not satisfied in a specific case that a special factor is the correct approach to ensuring the necessary integrity of the parts of the structure under service conditions, other appropriate measures must be taken.

Thank You
Any Questions