

**NOTICE OF PROPOSED AMENDMENT (NPA) No 8-2004**  
**DRAFT DECISION OF THE EXECUTIVE DIRECTOR OF THE AGENCY,**  
**on certification specifications for large aeroplanes (CS-25)**

**Contents**

This Notice of Proposed Amendment is made up of four different parts:

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Describing the development process and explaining the contents of the proposal.
- B. Proposals**  
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- C. Original JAA NPA proposals justification**  
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- D. JAA NPA Comment-Response Document**  
This part summarizes the comments made on the JAA NPA and the responses to those comments.

## A. Explanatory Note

### I. General

1. The purpose of this Notice of Proposed Amendment (NPA) is to propose changes to the certifications specifications for large aeroplanes (CS-25). The reason for this proposal is outlined further below. This measure is included in the Agency's 2004 Rulemaking programme.

2. The text of this NPA was developed by the JAA Structures Steering Group. It was adapted to the EASA regulatory context by the Agency. It is now submitted for consultation of all interested parties in accordance with Article 5(3) of the EASA rulemaking procedure<sup>1</sup>. The review of comments will be made by the Agency unless the comments are of such nature that they necessitate the establishment of a group.

### II. Consultation

3. In November 1997 the JAA published NPA 25D-272 for comment. Discussion on Casting Factors has since then continued within the JAR/FAR 25 harmonisation framework. The comments received on the November 1997 issue of the JAA NPA (as far as they were accepted and are still applicable) have been incorporated into this issue (Revision 1) of the NPA.

Because the content of this NPA was not yet agreed for adoption in the Joint Aviation Authorities (JAA) system and its current version was not the subject of a full worldwide consultation, the standard three months consultation period is applied. However, in view of the consultation by the JAA in November 1997 (see above) the requirement to produce a full Regulatory Impact Assessment is exempted based on the transitional arrangements of Article 15 of the EASA rulemaking procedure. Part C of this NPA contains a Cost/Safety Benefit Assessment

4. To achieve optimal consultation, the Agency is publishing the draft decision on its internet site in order to reach its widest audience and collect the related comments.

Comments on this proposal may be forwarded (*preferably by e-mail*), using the attached comment form, to:

**By e-mail:** [NPA-8-2004@easa.eu.int](mailto:NPA-8-2004@easa.eu.int)

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Comments should be received by the Agency **before 25 January 2005** and if received after this deadline they might not be treated. Comments may not be considered if the form provided for this purpose is not used.

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<sup>1</sup> Decision of the Management Board concerning the procedure to be applied by the Agency for the issuing of opinions, certification specifications and guidance material ("rulemaking procedure"), EASA MB/7/03, 27.6.2003.

### **III. Comment response document**

5. All comments received will be responded to and incorporated in a Comment Response Document (CRD). This will contain a list of all persons and/or organisations that have provided comments. The CRD will be widely available ultimately before the Agency adopts its final decision.

### **IV. Content of the draft Decision**

6. The initial issue of CS-25 was based upon JAR-25 at amendment 16. During the transposition of airworthiness JARs into certification specifications the rulemaking activities under the JAA system were not stopped. In order to assure a smooth transition from JAA to EASA the Agency has committed itself to continue as much as possible of the JAA rulemaking activities. Therefore it has included most of it in its own rulemaking programme for 2004 and planning for 2005-2007. This EASA NPA is a result of this commitment and a transposed version of the JAA NPA 25D-272 at Revision 1 which was accepted for circulation for comments by the JAA Regulation Sectorial Team in March 2003.

7. In 1993, the Aviation Rulemaking Advisory Committee (ARAC) chartered by notice in the Federal Register a General Structures Harmonisation Working Group (GSHWG) of industry and government structural specialists of Europe, the United States and Canada, to work on a number of issues to harmonise Part 25 of the Federal Aviation Regulations (FAR 25) and the European Joint Airworthiness Requirements for Large Aeroplanes, JAR-25. One of these issues (tasked in the Federal Register in September 1998) was Casting Factors.

In November 1997 the JAA published NPA 25D-272 for comment. Discussion on Casting Factors has since then continued within the JAR/FAR 25 harmonisation framework as explained above. The comments received on the November 1997 issue of this NPA (as far as they were accepted and are still applicable) have been incorporated into this issue (Revision 1) of the NPA.

This NPA proposes a specific casting factor requirement for CS-25, with accompanying AMC material, as developed and agreed (June 2002, Long Beach) by the GSHWG. This action will eliminate the use of national standards and thus harmonise the requirement for EASA. In addition, the requirement has been written with regard the changes in structural design certification philosophy, as well as advances casting technology. The aviation industries approach to the use of structural castings has changed little in the last 30 years. However significant advances in casting technology have occurred along with better understanding of the parameters that influence the quality of cast components. The current national standards do not give a possibility to take credit for these advances. The new paragraph of CS-25 proposed along with guidance material on how and when such credit can be taken. The format and approach of FAR 25.621 has been adapted to develop the new CS 25.621 requirement.

Harmonisation of this requirement and associated guidance material will ensure that, similar casting factors and testing will be required in the substantiation of cast structural components, as well as the same production inspection regime by the US and European Authorities.

## B. PROPOSALS

*The following amendments should be included in Decision No. 2003/2/RM of the Executive Director of the Agency of 17 October 2003:*

### 1. Delete the existing text in CS 25.621 and replace with new text as follows:

#### **CS 25.621 Casting factors.**

(see AMC 25.621.)

(a) *General.* For castings used in structural applications, the factors, tests, and inspections specified in sub-paragraphs (b) through (d) of this paragraph must be applied in addition to those necessary to establish foundry quality control. The inspections must meet approved specifications. Sub-paragraphs (c) and (d) of this paragraph apply to any structural castings except castings that are pressure tested as parts of hydraulic or other fluid systems and do not support structural loads.

(b) *Bearing stresses and surfaces.* The casting factors specified in sub-paragraph (c) of this paragraph-

(1) Need not exceed 1.25 with respect to bearing stresses regardless of the method of inspection used; and

(2) Need not be used with respect to the bearing surfaces of a part whose bearing factor is larger than the applicable casting factor.

(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. Examples of castings that may be critical are: structural attachment fittings; parts of flight control systems; control surface hinges and balance weight attachments; seat, berth, safety belt, fuel, and oil tank supports and attachments; pressurised doors; and cabin pressure valves. 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 greater than or equal to 1.0 but less than 1.25 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. Process monitoring must include testing of coupons cut from the prolongations of each casting (or each set of castings, if produced from a single pour into a single mould in a runner system) and, on a sampling basis, coupons cut from critical areas of production castings. The acceptance criteria for the process monitoring inspections and tests must be established and included in the process specifications to ensure the properties of the production castings are controlled to within levels used in design.

(ii) Each casting receives:

(A) Inspection of 100 percent of its surface, using visual and liquid penetrant, or equivalent, inspection methods; and

(B) Inspection of structurally significant internal areas and areas where defects are likely to occur, using radiographic, or equivalent, inspection methods.

- (iii) One casting undergoes a static test and is shown to meet the strength and deformation requirements of CS 25.305.  
(see AMC 25.621(c)(1).)
- (2) A casting factor of greater than or equal to 1.25 but less than 1.50 may be used, provided that --
  - (i) Each casting receives:
    - (A) Inspection of 100 percent of its surface, using visual and liquid penetrant, or equivalent inspection methods; and
    - (B) Inspection of structurally significant internal areas and areas where defects are likely to occur, using radiographic, or equivalent, inspection methods.
  - (ii) Three castings undergo static tests and are shown to meet:
    - (A) The strength requirements of CS 25.305 at an ultimate load corresponding to a casting factor of 1.25; and
    - (B) The deformation requirements of CS 25.305 at a load of 1.15 times the limit load.
- (3) A casting factor of 1.50 or greater may be used, provided that --
  - (i) Each casting receives:
    - (A) Inspection of 100 percent of its surface, using visual and liquid penetrant, or equivalent, inspection methods; and
    - (B) Inspection of structurally significant internal areas and areas where defects are likely to occur, using radiographic, or equivalent, inspection methods.
  - (ii) One casting undergoes a static test and is shown to meet:
    - (A) The strength requirements of CS 25.305 at an ultimate load corresponding to a casting factor of 1.50; and
    - (B) The deformation requirements of CS 25.305 at a load of 1.15 times the limit load.
- (d) *Noncritical castings.* For each casting other than critical castings, as specified in subparagraph (c) of this paragraph, the following apply:
  - (1) A casting factor of greater than or equal to 1.0 but less than 1.25 may be used, provided that the requirements of (c)(1) of this paragraph are met, or:
    - (i) Castings are manufactured to approved specifications that specify the minimum mechanical properties of the material in the casting and provides for demonstration of these properties by testing of coupons cut from the castings on a sampling basis.
    - (ii) Each casting receives:
      - (A) Inspection of 100 percent of its surface, using visual and liquid penetrant, or equivalent, inspection methods; and
      - (B) Inspection of structurally significant internal areas and areas where defects are likely to occur, using radiographic, or equivalent, inspection methods.
    - (iii) Three sample castings undergo static tests and are shown to meet the strength and deformation requirements of CS 25.305.
  - (2) A casting factor of greater than or equal to 1.25 but less than 1.50 may be used, provided that each casting receives:
    - (i) Inspection of 100 percent of its surface, using visual and liquid penetrant, or equivalent, inspection methods; and

- (ii) Inspection of structurally significant internal areas and areas where defects are likely to occur, using radiographic, or equivalent, inspection methods.
- (3) A casting factor of greater than or equal to 1.5 but less than 2.0 may be used, provided that each casting receives inspection of 100 percent of its surface using visual and liquid penetrant, or equivalent, inspection methods.
- (4) A casting factor of 2.0 or greater may be used, provided that each casting receives inspection of 100 percent of its surface using visual inspection methods.
- (5) The percentage of castings inspected by non-visual methods in accordance with sub-paragraphs (d)(2) and (d)(3) of this paragraph may be reduced when an approved quality control procedure is established.

**2. Add a new AMC to CS 25.621 as follows:**

**AMC 25.621**

**Casting Factors**

**(Acceptable Means of Compliance)**

1. *Purpose.*

1.1 CS 25.621 is an additional rule/requirement for structural substantiation of cast parts and components. It is used in combination with a number of other paragraphs, and does not replace or negate compliance with any other paragraph of CS 25. The intent of this AMC is to provide general guidance on the use and background of "Casting Factors" as required by CS 25.621.

2. *General Guidance For Use Of Casting Factors.*

2.1 For the analysis or testing required by CS 25.307, the ultimate load level must include limit load multiplied by the required factor required by CS 25.619. The testing required in accordance with CS 25.621 may be used in showing compliance with CS 25.305 and CS 25.307. These factors need not be considered in the fatigue and damage tolerance evaluations required by CS 25.571.

2.2 The inspection methods prescribed by CS 25.621(c) and (d) for all production castings must be such that 100% of the castings are inspected by visual and liquid penetrant techniques, with total coverage of the surface of the casting. With regard to the required radiographic inspection, each production casting must be inspected by this technique or equivalent inspection methods; the inspection may be limited to the structurally significant internal areas and areas where defects are likely to occur.

2.3 With the establishment of consistent production, it is possible to reduce the inspection frequency of the non-visual inspections required by the rule for non-critical castings, with the approval of the Agency. This is usually accomplished by an approved quality control procedure incorporating a sampling plan. [Refer to CS 25.621(d)(5).]

2.4 The static test specimen(s) should be selected on the basis of the foundry quality control inspections, in conjunction with those inspections prescribed in CS 25.621(c) and (d).

An attempt should be made to select the worst casting(s) from the first batch produced to the production standard.

2.5 If applicable, the effects on material properties due to weld rework should be addressed. The extent and scope of weld rework should be detailed in the manufacturing specifications as well as on the design drawings.

### 3. *Background.*

3.1 *Regulatory Background.* CS 25.621 (“Casting factors”) requires classification of structural castings as either “critical” or “non-critical.” Depending on classification, the requirement specifies the accomplishment of certain inspections and tests, and the application of special factors of safety for ultimate strength and deformation.

3.2 *Application of Special Factors of Safety.* The application of factors of safety applied to castings is based on the fact that the casting process can be inconsistent. Casting is a method of forming an object by pouring molten metal into a mould, allowing the material to solidify inside the mould, and removing it when solidification is complete. Castings are subject to variability in mechanical properties due to this casting process, which can result in imperfections, such as voids, within the cast part. Using certain inspection techniques, for example radiographic (X-ray), it is possible to detect such imperfections above a minimum detectable size, but accurate detection depends on the dimensions of the part, the inspection equipment used, and the skill of the inspector.

3.2.1 CS 25.619 (“Special factors”) includes a requirement to apply a special factor to the factor of safety prescribed in CS 25.303 for each part of the aeroplane structure whose strength is subject to appreciable variability because of uncertainties in the manufacturing processes or inspection methods. Since the mechanical properties of a casting depend on the casting design, the design values established under CS 25.613 (“Material strength properties and design values”) for one casting might not be applicable to another casting made to the same specification. Thus, casting factors have been necessary for castings produced by normal techniques and methodologies to ensure the structural integrity of castings in light of these uncertainties.

3.2.2 Another approach is to reduce the uncertainties in the casting manufacturing process by use of a “premium casting process” (discussed in AMC 25.621(c)(1)), which provides a means of using a casting factor of 1.0. CS 25.621 (“Casting factors”) does permit the use of a casting factor of 1.0 for critical castings, provided that:

- the manufacturer has established tight controls for the casting process, inspection, and testing; and
- the material strength properties of the casting have no more variability than equivalent wrought alloys.

### 3. **Add a new AMC to CS 25.621(c)(1) as follows:**

#### **AMC 25.621(c)(1)**

#### **Premium Castings**

#### **(Acceptable Means of Compliance)**



1. *Purpose.* This AMC details an acceptable means, but not the only means, for compliance with CS 25.621 for using a casting factor greater than or equal to 1.0, but less than 1.25, 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 1.00 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.

2. *Definitions.* For the purposes of this AMC, the following definitions apply:

- 2.1 *Premium Casting Process:* a casting process that produces castings characterised by a high quality and reliability
- 2.2 *Prolongation:* an integrally cast test bar or test coupon.
- 2.3 *Test Casting:* a casting produced specifically for the purpose of qualifying the casting process.

3. *General.* 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
- Good surface finish
- No cracks
- No cold shuts
- No laps
- Minimal shrinkage cavities
- No harmful entrapped oxide films
- Minimal porosity
- A high level of metallurgical cleanliness
- Good microstructural characteristics
- Minimal residual internal stress
- Consistent mechanical properties

The majority of these characteristics can be detected, evaluated, and quantified by standard non-destructive testing methods, or from destructive methods on prolongation or casting cut-up tests. However, a number of them cannot. Thus, to ensure an acceptable quality of product, the significant and critical process variables must be identified and adequately controlled.

4. *A Means of Qualification of Casting Process.*

4.1 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 (i.e., plate, extrusions, and bar). Usage of the population coefficient of variation from forged products does not apply. 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.

4.2 For each material specification, a series of test castings from a number of melts, using the appropriate production procedures of the foundry, should be manufactured. The test casting produced should undergo a standardised inspection or investigation of non-destructive inspection and cut-up testing, to determine the consistency of the casting process.

4.3 The test casting should be representative of the intended cast product(s) with regard to section thicknesses and complexity, and should expose any limitations of the casting process. In addition, the test casting should be large enough to provide mechanical test specimens from various areas, for tensile and, if applicable, compression, shear, bearing, fatigue, fracture toughness, and crack propagation tests. If the production component complies with these requirements, it may be used to qualify the process. The number of melts sampled should be statistically significant. Typically, at least 10 melts are sampled, with no more than 10 castings produced from each melt. If the material specification requires the components to be heat-treated, this should be done in no fewer than 10 heat treatment batches consisting of castings from more than one melt. Reduction of qualification tests may be considered if the casting process and the casting alloy is already well known for aerospace applications and the relevant data are available.

4.4 Each test casting should receive a non-destructive inspection program which should include as a minimum:

- inspection of 100% of its surface, using visual and liquid penetrant, or equivalent, inspection methods; and
- inspection of structurally significant internal areas and areas where defects are likely to occur, using radiographic methods or equivalent inspection methods. The specific radiographic standard to be employed is to be determined, and the margin by which the test castings exceed the minimum required standard should be recorded.

4.4.1 The program of inspection is intended to;

- (a) confirm that the casting process is capable of producing a consistent quality of product, and
- (b) verify compliance with the stated objectives of a premium casting process with regard to surface finish, cracks, cold shuts, laps, shrinkage cavities, and porosity, (see paragraph 3), and
- (c) ensure that the areas from which the mechanical property test samples were taken were typical of the casting as a whole with respect to porosity and cleanness.

4.4.2 Guidance on non-destructive inspection techniques and methods can be obtained from national and international standards. The standard listing below is not a comprehensive list but is given as an initial reference guide.

ASTM A802 Standard practice for steel castings, surface acceptance standards, visual examination.

ASTM A903 Standard specification for steel castings, surface acceptance standards, magnetic particle and liquid penetrant inspection.

ASTM E155 Standard Reference Radiographs for Inspection of Aluminum and Magnesium Castings.

ASTM E192 Standard Reference Radiographs for Investment Steel Castings of Aerospace Applications.

ASTM E433 Standard reference photographs for liquid penetrant inspection.

ASTM E1030 Standard test method for radiographic examination of metallic castings.

ASTM E1320 Standard Reference Radiographs for Titanium Castings.

ISO 4986 Steel castings -- Magnetic particle inspection

ISO 4987 Steel castings -- Penetrant inspection

ISO 4993 Steel castings -- Radiographic inspection

ISO 9915 Aluminium alloy castings -- Radiography testing

ISO 9916 Aluminium alloy and magnesium alloy castings -- Liquid penetrant inspection

ISO 10049 Aluminium alloy castings -- Visual method for assessing the porosity

ISO 11971 Visual examination of surface quality of steel castings

The test castings must show that the Foundry/Process combination is capable of producing product free of cracks, laps, and cold shuts. Ideally the test castings should be free of detectable shrinkage cavities and porosity. With regard to dimensional tolerance, distortion, and surface finish guidance for acceptance criteria can be gained from the standards cited above. Consideration that these standards are for general quality castings must be given when they are used.

4.5 All test castings should be cut up to a standardised methodology to produce the mechanical test specimens as detailed by paragraph 4.3 above. Principally, the tests are to establish the variability within the cast component, as well as to determine the variability between components from the same melt and from melt to melt. The data gathered also may be used during latter phases to identify deviations from the limits established in the process qualification and product proving programs.

4.6 All the fracture surfaces generated during the qualification program should be inspected at least visually for detrimental defects. Evidence of inclusions, oxide films, porosity or shrinkage cavities would indicate inadequate control of the casting process.

4.7 As part of the cut-up investigation, it is usually necessary to take metallographic samples for cleanness determination and microstructural characterisation.

4.9 When the process has been qualified, it should not be altered without completing comparability studies and necessary testing of differences.

## 5. *Proof of Product*

5.1 Subsequent to the qualification of the process, the production castings should be subjected to a production-proving program. Such castings should have at least one prolongation; however, large and/or complex castings may require more than one. If a number of castings are produced from a single mould with a single runner system, they may be treated as one single casting. 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.
- (d) The prolongation(s) is representative of the critical area(s) of the casting.
- (e) The prolongation(s) consistently reflects the quality process, and material properties of the casting.

5.2 A number of (i.e., at least two) pre-production castings of each part number to be produced should be selected for testing and inspection. All of the selected castings should be non-destructively inspected in accordance with the qualification program.

- (a) One of these castings should be used as a dimensional tolerance test article. The other selected casting(s) should be cut up for mechanical property testing and metallographic inspection.
- (b) The casting(s) should be cut up to a standardised program to yield a number of tensile test specimens and metallographic samples. There should be sufficient cut-up tensile specimens to cover all critical (“critical” with respect to both the casting process and service loading) areas of the casting.
- (c) All prolongations should be machined to give tensile specimens, and subsequently tested.
- (d) The production castings should be produced to production procedures identical to those used for these pre-production castings.

5.3 On initial production, a number of castings should undergo a cut-up for mechanical property testing and metallographic inspection, similar to that performed for the pre-production casting(s). The cut-up procedure used should be standardised, although it may differ from that used for the pre-production casting(s). Tensile specimens should be obtained from the most critical areas.

- (a) For the first 30 castings produced, at least 1 casting in 10 should undergo this testing program.

(b) The results from the mechanical property tests should be compared with the results obtained from the prolongations to further substantiate the correlation between prolongation(s) and the critical area(s) of the casting.

(c) In addition, if the distribution of mechanical properties derived from these tests is acceptable, when compared to the property values determined in the qualification program, the frequency of testing may be reduced. However, if the comparison is found not to be acceptable, the test program may require extension.

5.4 At no point in the production should the castings contain shrinkage cavities, cracks, cold shuts, laps, porosity, or entrapped oxide film, or have a poor surface finish, exceeding the acceptance level defined in the technical specifications.

## 6. *Monitoring the Process.*

6.1 For the product quality techniques should be employed to establish the significant/critical foundry process variables that have an impact on the quality of the product. For the product it should be shown that these variables are controlled with positive corrective action throughout production.

6.2 During production, every casting should be non-destructively inspected using the techniques and the acceptance standards employed during the qualification program.

(a) Rejections should be investigated and process corrections made as necessary.

(b) Alternative techniques may be employed if the equivalence in the acceptance levels can be demonstrated.

(c) In addition, tensile tests should be taken from the prolongations on every component produced, and the results should comply with limits developed in the process qualification and product proving programs.

(d) Additionally, as previously mentioned, a periodic casting cut-up inspection should be undertaken, with the inspection schedule as agreed upon during the proof of product program.

(e) Deviations from the limits established in the process qualification and product proving programs should be investigated and corrective action taken.

## 7. *Modifications to the Casting Design, Material, and Process.*

7.1 Additional testing may be required when alterations are made to the casting geometry, material, significant/critical process variables, process, or production foundry to verify that the alterations have not significantly changed the castings' properties. The verification testing recommended is detailed in Table 1, below:

**TABLE 1. Recommended Verification Testing**

<b>Modifications</b>					<b>Verification Testing</b>		
<b>Case</b>	<b>Geometry</b>	<b>Material</b>	<b>Process</b>	<b>Foundry</b>	<b>Qualification of Process</b>	<b>Proof of Product</b>	<b>Tests per CS 25.621(c)(1)</b>
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)
<p>(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:</p> <ol style="list-style-type: none"> <li>(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.</li> <li>(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.</li> <li>(3) Clearly defined material and process specifications.</li> </ol> <p>(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); this should be approved.</p>							

## C. ORIGINAL JAA NPA PROPOSALS JUSTIFICATION

### 1. SAFETY JUSTIFICATION / EXPLANATION

Prior to the issuance of JAR-25 a number of JAA national authorities had their own certification requirements (national standards) covering casting factors in the design of large aeroplanes, others applied the American requirements. Thus, paragraph 621 "Casting Factors" in the current JAR-25 is as follows:

*"The approved national standards of the participants are accepted by the Authorities as alternatives to FAR 25.621."*

Cast metallic parts have historically exhibited certain manufacturing defects more frequently than other metallic parts because of the manufacturing process for making castings. The most common defects in castings are voids and inclusions. Voids and inclusions are not always detectable in the part after it is cast, but they can affect its strength and structural fatigue properties. The net result is a large variability in strength properties of castings compared to wrought structural products. FAR 25.621 and the national standards established certain special safety factors (casting factors) to be used in the strength substantiation of the design, production inspections, and certification tests for castings to account for their special manufacturing issues.

Over the last decade research has advanced the understanding of the critical casting parameters that has led to improvements in the technology. With the use of selected casting methods and adequate process control the variability in the mechanical properties can be reduced to levels comparable to wrought metal products. The new requirement has been written to take advantage of these developments, as well as covering the older casting methodologies.

As previously indicated JAR 25.621 had no specific requirement covering castings. This NPA proposes the introduction of a new requirement that takes account of advances in casting technology. The new requirement is based on FAR 25.621, for ease of understanding. The amendments are summarised and discussed below.

To align this requirement with the philosophies of JAR 25.571 the first sentence of JAR 25.621(c) has been revised to replace the word "would" with the word "could," so that it reads as follows:

**"(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 to be a critical casting."**

Due to the perception that cast components have inconsistent variability in material strength properties, BCAR D4-1 paragraph 4.3 and FAR 25.619, both invoke the use of special factors for these components. This was valid 30 years ago. However the imposition of strict casting factors effectively precluded the use of castings as structural components in aircraft. Over the last decade or so, there have been significant advances in casting technology along with understanding of the parameters that influence the quality of the cast components. These advances have made it possible to produce castings that show material strength variability similar to that of wrought materials. Thus, this proposal permits the use of a casting factor of 1.0 for critical castings, but only provided that tight controls are established for the casting

process, inspection, and testing, and that material strength properties have no more variability than equivalent wrought alloys.

During production each critical casting must receive visual and special non-destructive inspections and that any flaws smaller than detectable would not reduce the properties of the casting below that for which certification is shown. However, for large parts, not all areas of which may be sensitive to certain flaw types, the special non-destructive inspections could be limited to specified areas of the casting. This is provided that visual inspections would be capable of detecting the specified flaws for which certification is demonstrated.

Static tests would still be required for parts to which a casting factor of 1.0 would be applied; however, only one sample would need to be tested. This is considered, appropriate because the material variability of such castings is similar to that of wrought alloys

For a casting factor of 1.0 to be applied to a part, the qualification program would have to ensure that the casting method is able to produce a consistent product, with uniform properties throughout the casting. To help assure quality, test castings from several melts, using foundry production procedures, would be inspected; cut up and inspected; metallographically examined; and tested for mechanical properties. Further guidance describing in detail a means for satisfying the requirements associated with the use of a casting factor of 1.0 has been included in the proposed ACJ 25.621(c)(1).

The current use of casting factors for critical applications often results in enough of a weight penalty that manufacturers will use other, more expensive processes out of necessity. The use of a casting factor of 1.0 for critical castings, as proposed in this NPA, would eliminate the weight penalty of the current requirement and enable less costly castings to be used in place of forgings, assembled structure, or machined parts.

[Although the proposed rule covers a range of casting factors greater than 1.0, it is anticipated that applicants will actually use the lower value of each range of values (i.e., factors of 1.0, 1.25, 1.50, 2.0), since there would be no advantage to using a higher number in a given band.]

## 2. COST / SAFETY BENEFIT ASSESSMENT

The proposals, although introduce a new requirement into JAR 25, do not substantively change the casting factor requirements used at present within the JAA countries. The major change is to reduce the minimum casting factor for critical castings to 1.00. Although these castings will have less direct testing, there will be considerably more indirect testing to qualify the technique as well as a greater degree of process control. The likely consequence of this change is the increased use of castings as structural components with in aeroplanes. As the quality of these structural castings will be similar to that of wrought metallic components there will be no adverse effects on the safety of future aeroplanes.

The introduction of this proposal will allow greater use of castings as structural components and thus give the designer the ability to produce more efficient aeroplane structure.



**D. JAA NPA COMMENT-RESPONSE DOCUMENT**

. In November 1997 the JAA published NPA 25D-272 for comment. Discussion on Casting Factors has since then continued within the JAR/FAR 25 harmonisation framework. The comments received on the November 1997 issue of the JAA NPA (as far as they were accepted and are still applicable) have been incorporated into this issue (Revision 1) of the NPA.

There is however no JAA NPA Comment Response Document available for the latest JAA NPA version which is presented here.