

MIL-STD-1869(AT)  
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SUPERSEDING  
(see 6.3)

MILITARY STANDARD  
TURBINE BLADES AND VANES, CAST;  
ACCEPTANCE CRITERIA FOR



AMSC N/A

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FSC 2835

MIL-STD-1869(AT)

DEPARTMENT OF DEFENSE  
WASHINGTON, DC 20301

Turbine Blades and Vanes, Cast; Acceptance Criteria for

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FOREWORD

This standard provides a means of insuring high-quality turbine blades and vanes.

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1. SCOPE

1.1 Scope. This standard covers the acceptance criteria for cast and finish-machined turbine blades and vanes, and blades assembled into wheels.

1.2 Purpose. The purpose of this standard is to insure turbine blades and vanes meet prescribed material acceptance criteria.

1.3 Classification. Classification shall be as follows:

Type I	- Air-cooled turbine blades.
Type II	- Solid turbine blades.
Type III	- Turbine vanes.

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## 2. REFERENCED DOCUMENTS

2.1 Issues of documents. The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of this standard to the extent specified herein.

STANDARDS  
MILITARY

MIL-STD-453	- Inspection, Radiographic.
MIL-STD-1870	- Grain Size, Cast Turbine Blades, Acceptance Criteria for.
MIL-STD-6866	- Inspection, Liquid Penetrant.

(Copies of standards required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following document forms a part of this standard to the extent specified herein. Unless otherwise specified, the issue of the document which is DOD adopted shall be that listed in the issue of the DODISS specified in the solicitation. The issue of the document which has not been adopted shall be that in effect on the date of the cited DODISS.

## SOCIETY OF AUTOMOTIVE ENGINEERS, INC. (SAE)

AS 478	- Identification Marking Methods.
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(Application for copies should be addressed to the Society of Automotive Engineers, Inc., 400 Commonwealth Avenue, Warrendale, PA 15096.)

(Nongovernment standards and other publications are normally available from the organizations which prepare or which distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence.

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## 3. DEFINITIONS

3.1 Casting lot. A casting lot is a group of castings with the same part number and revision letter, poured from one master heat of metal and using the same casting process parameters and type of preheat and casting furnace.

3.2 Coating. A coating is a material bonded to the base metal of the turbine blade or vane.

3.2.1 Chip. A chip is an area of the coating which has been removed by a portion of the coating being flaked off. Chipping occurs most often along coating edges.

3.2.2 Spall. A spall is an area of the coating which has come off the coated area due to lack of bond to the base metal.

3.2.3 Blister. A blister is an area of coating raised above the plane of the coating due to lack of bond to the base metal.

3.2.4 Burnish. A burnish is an area of the coating which has a luster or polish.

3.2.5 Crazing. Crazing is an area of the coating in which the formation of minute cracks occurs, usually attributed to shrinkage or sometimes to moisture.



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## 5. DETAILED REQUIREMENTS

5.1 Acceptance criteria.5.1.1 Type I.5.1.1.1 Limits for imperfections (visual and fluorescent penetrant).

Limits for imperfections for acceptance of turbine blade castings, determined visually and with fluorescent penetrant in accordance with MIL-STD-6866, shall be as follows:

- a. No evidence of cracks, dross, cold shuts, hot tears, linear or crack-like indications, or linear inclusions.
- b. Unratable imperfections, pits, blowholes, bottomed porosity, indications, etc. shall be within the allowable limits specified in table I.
- c. There shall be no evidence of positive metal on airfoil surfaces to be coated.
- d. The limits of table I may be exceeded on the as-cast surfaces provided the allowable limits of table I can be met after machining.
- e. Mold ridges, fins, and gate witnesses shall not exceed 0.030 inch in height. On the airfoil surfaces, mold ridges, fins, and gate witnesses shall not be permitted.

5.1.1.2 Indications of imperfections (radiographic). Indications of imperfections in turbine blade castings, determined by radiography in accordance with MIL-STD-453, shall be acceptable in the specified area (see table I and figures 1 and 3) provided identifiable indications do not exceed the following limits:

- a. Casting area A. Identifiable indications in casting area A shall not be acceptable.
- b. Casting areas B and C:
  - (1) Cracks, abnormal segregation, cold shuts, misruns, and hot tears shall not be acceptable.
  - (2) Porosity, inclusions, positive metal, and shrinkage shall be acceptable provided the indications do not exceed 0.020 inch dimension or number more than four indications per blade casting and are not less than 0.25 inch apart.

5.1.1.3 Surface coating. Surface coating areas of turbine blades shall meet the acceptance criteria of the applicable turbine blade drawing and the exceptions specified herein.

5.1.1.3.1 Burnish marks. Burnish marks (see 3.2.4) shall be permitted on the coating of turbine blades provided the coating is not removed below the allowable drawing thickness specified.

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5.1.1.3.2 Unacceptable defects. There shall be no evidence of defects on turbine blade airfoil and platform such as chips, spalls, blisters, and crazing (see 3.2) of the coating beyond the shaded areas illustrated in figure 4.

5.1.1.3.3 Indentation and surface irregularities. Indentation and surface irregularities on turbine blade castings which meet applicable drawing dimensional requirements shall be acceptable provided the coating is entire throughout the indented and irregular areas.

5.1.1.3.4 Acceptable defects.

5.1.1.3.4.1 Airfoil tip and platform. Defects shall be allowed on the blade airfoil for a distance of 0.13 inch below the blade tip and on the blade platform (excluding the platform airfoil fillet radius) as noted in figure 4. The following limits apply:

- a. Defects over 0.06 inch dimension shall not be acceptable.
- b. Defects 0.03 to 0.06 inch dimension shall be acceptable provided there are not more than two per blade side.
- c. Defects under 0.03 inch dimension shall be acceptable provided there are not more than a combined total of six defects of any size on any one blade per side.
- d. The distance of closest approach shall be not less than the maximum dimension of the smaller acceptable defect.

5.1.1.3.4.2 Airfoil leading and trailing edge.

- a. 0.030 inch maximum dimension.
- b. 0.25 inch distance of closest approach to another indication.
- c. All indications must originate at, or cross over the leading or trailing edge radius.

5.1.1.3.5 Root area masking and coating limits. Coating applied to turbine blade root areas after machining is completed shall meet the limits specified on the applicable turbine blade drawing and the following requirements after masking material is removed:

- a. Rejectable masking and coating material indications:
  - (1) Masking or coating material exceeds 0.031 inch dimension.
  - (2) More than five areas containing masking or coating material found in any one root area.
  - (3) The distance of closest approach between areas is less than 0.125 inch.
  - (4) The remaining material (masking or coating) forms a fillet over 0.010 inch in the machined grooves.

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- b. Acceptable masking and coating material areas:
- (1) Bottom of blade root: Areas of any size which do not extend into the radii of the machined and peened areas and do not exceed the maximum dimension shown on the applicable turbine blade drawing.
  - (2) Area between machined ball root and platform edge (excluding the machined grooves): Areas up to 0.187 inch dimension.

5.1.1.3.6 Machined cooling holes and plug core positioning holes. Machined cooling holes shall be open and functional. Plugged holes and cooling holes shall meet applicable drawing requirements and the following:

- a. Cooling holes along trailing edge of airfoil and plug core positioning holes shall conform to the applicable drawing requirements.
- b. Cored passages shall not be blocked or restricted by foreign materials (e.g., core materials, coating powder, base material, etc.).

5.1.2 Type II.

5.1.2.1 Limits for imperfections (visual and fluorescent penetrant). Limits for imperfections for acceptance of turbine blade castings, determined visually and with fluorescent penetrant in accordance with MIL-STD-6866, shall be as follows:

- a. No evidence of cracks, dross, cold shuts, hot tears, or linear or crack-like indications.
- b. Unratable imperfections, pits, blowholes, bottomed porosity, indications, etc. shall be within the allowable limits specified in table II.
- c. There shall be no evidence of positive metal in excess of that specified in table II.
- d. The limits of table II may be exceeded on the as-cast surfaces provided the allowable limits of table II can be met after machining.

5.1.2.2 Indications of imperfections (radiographic). Indications of imperfections in turbine blade castings, determined by radiography in accordance with MIL-STD-453, shall be acceptable in the specified area (see table II and figure 5) provided identifiable indications do not exceed the following limits:

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- a. Casting area A. Identifiable indications in casting area A shall not be acceptable.
- b. Casting areas B and C:
  - (1) Cracks, abnormal segregation, cold shuts, and hot tears shall not be acceptable.
  - (2) Porosity, inclusions, and shrinkage shall be acceptable provided the following limits are not exceeded:
    - (a) 0.030 inch dimension or number more than four indications per blade casting and are not less than 0.25 inch apart.
    - (b) 0.030 inch or 30 percent of wall thickness, whichever is smaller.

5.1.2.3 Grain size. Unless otherwise specified on the applicable drawing or MIL-STD-1870, the grain size of turbine blade castings shall be in accordance with the applicable material specification.

5.1.3 Type III.

5.1.3.1 Limits for imperfections (visual and fluorescent penetrant). Limits for imperfections for acceptance of turbine vane castings and finish-machined turbine vanes, determined visually and with fluorescent penetrant in accordance with MIL-STD-6866, shall be as follows:

- a. No evidence of cracks, dross, cold shuts, hot tears, or linear or crack-like indications.
- b. Unratable imperfections, pits, blowholes, bottomed porosity, indications, and positive metal shall be within the allowable limits specified in table III.
- c. There shall be no fins, gate witnesses, or mold ridges in excess of that specified in table III for positive metal.
- d. Table III limits may be exceeded on the as-cast surfaces provided allowable limits of table III can be met after machining.

5.1.3.2 Indications of imperfections (radiographic). Indications of imperfections in turbine vane castings, determined by radiography in accordance with MIL-STD-453, shall be acceptable in specified areas (see figure 6) provided identifiable indications do not exceed the following limits:

- a. Casting area A. Identifiable indications in casting area A shall not be acceptable. Isolated indications less than 0.010 inch shall be considered unratable.
- b. Casting areas B and C:
  - (1) Cracks, abnormal segregation, cold shuts, and hot tears shall not be acceptable.

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- (2) Porosity, inclusions, positive metal, and shrinkage shall be acceptable provided indications do not exceed 0.045 inch dimension or number more than four indications per casting. Isolated indications less than 0.015 inch shall be considered unratable.

5.1.3.3 Grain size. Acceptable grain size of turbine vane castings shall be in accordance with the applicable turbine vane drawing requirements and specifications.

5.1.3.4 Surface coating. Surface coating of turbine vanes shall meet the acceptance criteria of the applicable turbine vane drawing and the exceptions specified by typical coating acceptance limits (see figure 7).

5.1.3.4.1 Burnish marks. Burnish marks (see 3.2.4) shall be permitted on the coating of turbine vanes provided the coating is not removed below the allowable drawing thickness specified.

5.1.3.4.2 Unacceptable defects. A coating on turbine vanes is unacceptable if there is evidence of defects such as chips, spalls, blisters and crazing (see 3.1). Exceptions are indicated on figure 7.

5.1.3.4.3 Airfoil leading and trailing edge. Coating imperfections shall be allowed on the same airfoil leading and trailing edge within the following limits:

- a. 0.030 inch maximum dimension.
- b. 0.25 inch distance of closest approach to another indication.
- c. All indications must originate at, or cross over the leading or trailing edge radius.

## 5.2 Identification marking.

5.2.1 Types I and II. Turbine blade castings shall be identified in accordance with the applicable drawing and the following:

- a. Each casting shall be marked with the part number and revision letter on the airfoil in accordance with AS478, method 6A or 30.
- b. Each casting shall be marked with the casting source identifying letter (assigned by the acquisition activity) and casting lot number (see 3.1) on the root bottom in accordance with AS478, method 2B1 or 2C1.
- c. Each casting shall be marked with a symbol signifying the material as specified in the applicable material specification. The symbol shall be marked in the area specified on the applicable drawing in accordance with AS478, method 2B1 or 2C1. The symbol shall be marked in accordance with AS478, method 1A when so specified on the applicable drawing.
- d. Inspection stamp specified in MIL-STD-6866 and the applicable material specification shall not be required on subject castings.

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5.2.2 Type III. Turbine vane castings shall be identified on the airfoil in accordance with applicable drawing requirements. Each casting shall be marked with the part number and revision number, master heat or master heat code, and coating symbol, where applicable, in accordance with AS478, method 6A or 30.

5.3 Rework. Coated and uncoated turbine blade/vane castings or finish-machined turbine blades/vanes with imperfections exceeding the limits specified in the acceptance criteria (see 5.1) may be reworked provided the minimum dimensions and applicable drawing requirements are met. Coating on cast and finish-machined turbine blades/vanes shall be removed before rework.

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6. NOTES

6.1 Intended use. The procedures covered by this standard are intended to insure cast turbine blades and vanes meet prescribed material acceptance criteria.

6.2 Subject term (key word) listing.

Acceptance criteria  
Air-cooled  
Blades  
Cast  
Solid  
Turbine blades  
Turbine vanes  
Vanes

6.3 Supersession data. This standard supersedes AVCO Lycoming Division specification no. P7074D, dated 6 March 1986 (type I); P7077A, dated 26 April 1982 (type II); and P7073D, dated 6 November 1984 (type III).

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TABLE I. Visual and fluorescent penetrant acceptance limits (type I).

Type of indication	Casting area A	Casting area B	Casting area C
Unratable	0.005 inch or less maj. dim.	0.005 inch or less maj. dim.	0.005 inch or less maj. dim.
Pits, blowholes, bottomed porosity	Not allowed	0.030 inch maj. dim. 4 per side 0.250 inch at closest aprch.	0.030 inch maj. dim. 8 per side 0.250 inch at closest aprch.
Clusters of indications (Ratable plus unratable) Indv. ind. in cluster Ind. per cluster Max. size Clusters per side Dis. betw. clusters or single indications (Ratable or unratable)	Not allowed	0.010 inch maj. dim. 8 max. 0.10 inch maj. dim. 2 max.  0.060 inch min.	0.020 inch maj. dim. 8 max. 0.10 inch maj. dim. 2 max.  0.060 inch min.
Positive metal: Size Height Frequency Distance	0.030 inch maj. dim. 50% of maj. dim. up to 0.010 inch 4 per side 0.125 closest aprch.	0.030 inch maj. dim. 50% of maj. dim. up to 0.010 inch 4 per side 0.125 closest aprch.	0.030 inch maj. dim. 50% of maj. dim. up to 0.010 inch 8 per side 0.125 closest aprch.

## NOTES:

1. Clusters or single indications shall not be opposite, related, or interconnected.
2. Any ratable indication which breaks an edge shall be cause for rejection.
3. Where two surfaces of different classifications adjoin at a corner, the following conditions apply:
  - a. Casting areas B and C to casting area A surfaces: Allowable indications on casting area B or C surfaces must be 0.010 inch from the corner which adjoins a casting area A surface.
  - b. Casting area B or C surfaces: Allowable indications on a casting area B or C surface must be 0.005 inch from the corner which adjoins another casting area B or C surface.



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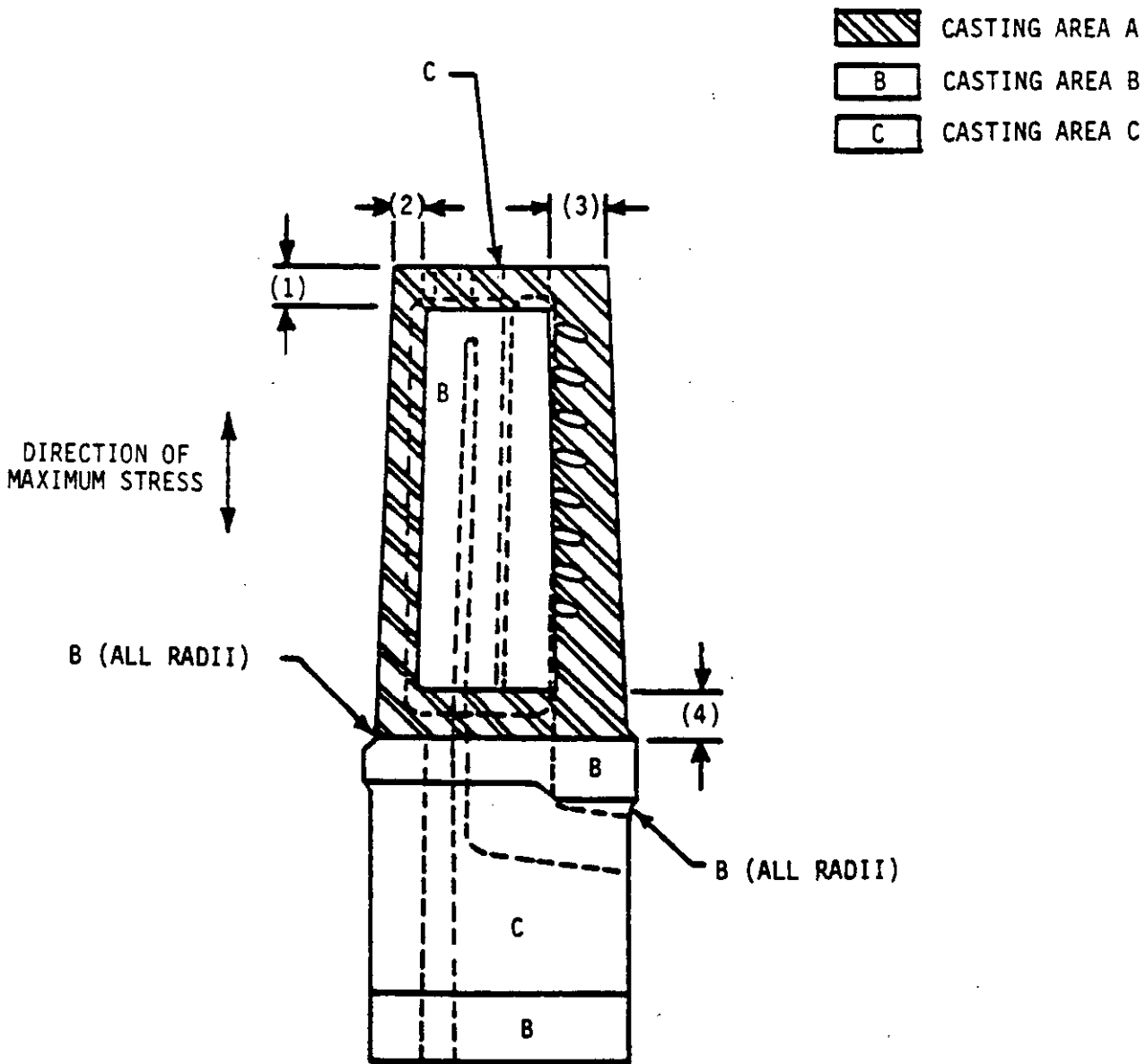


FIGURE 1. Typical casting areas (type I).

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## NOTES:

- (1) Casting area A down from the blade tip shall be equal to the blade tip nominal wall thickness specified on the applicable drawing plus 0.010 inch.
- (2) Casting area A along the leading edge on the concave and convex walls shall be equal to the nominal wall thickness of the leading edge at the maximum dimension specified on the applicable drawing.
- (3) Casting area A along the trailing edge on the concave and convex walls shall be equal to the average distance specified on the applicable drawing from rear core wall to the trailing edge.
- (4) Casting area A from the blade platform onto the concave and convex airfoil walls shall be equal to 25 percent of the blade length from the platform to the blade tip. This distance shall include the airfoil to platform fillet radii.

FIGURE 1. Typical casting areas (type I) (continued).

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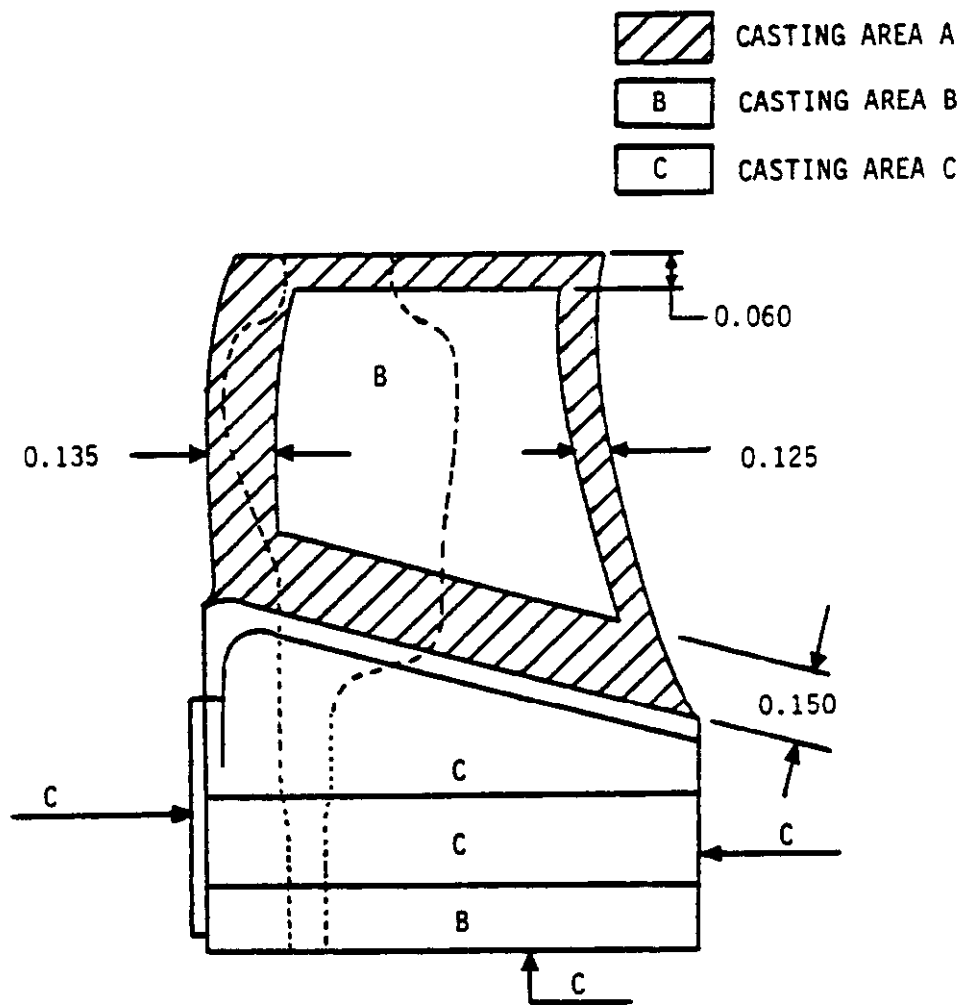
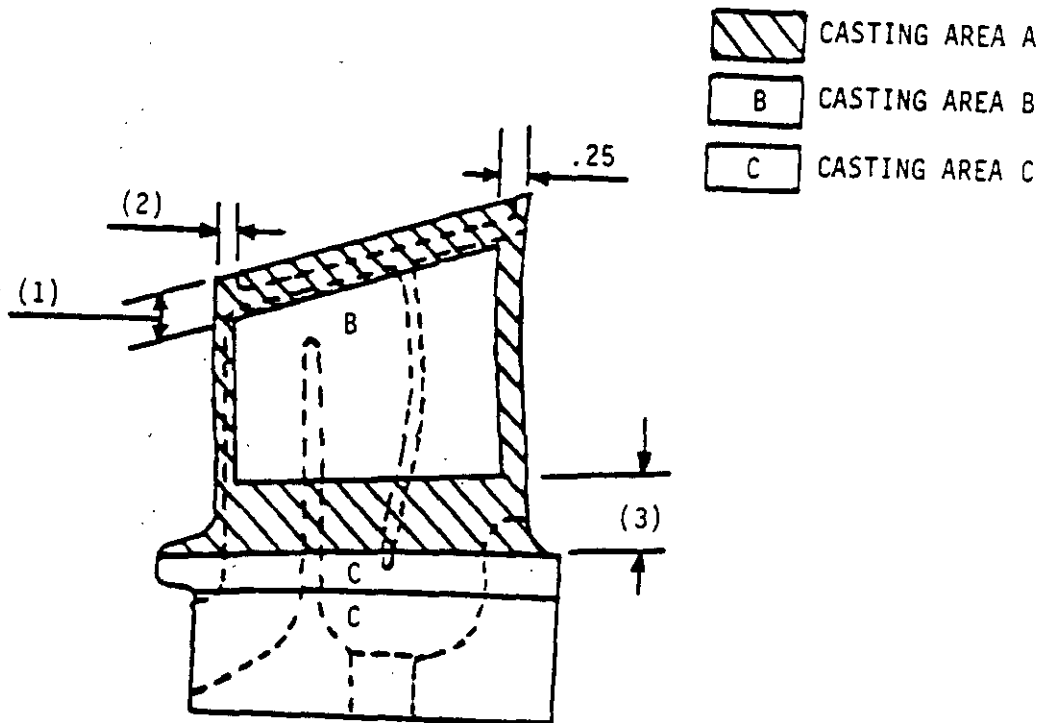


FIGURE 2. Typical casting areas (type I).

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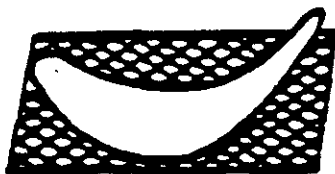


## NOTES:

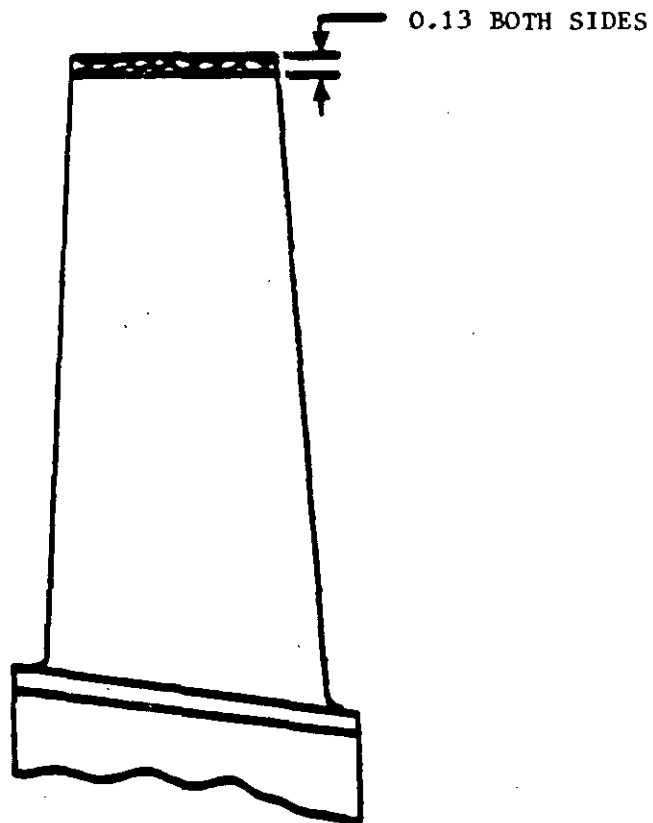
- (1) Casting area A down from the blade tip shall be equal to the nominal thickness of blade tip wall specified on the applicable drawing plus 0.010 inch.
- (2) Casting area A along the leading edge on the concave and convex walls shall be equal to two times the nominal wall thickness of the leading edge at the maximum dimension specified on the applicable drawing.
- (3) Casting area A from the blade platform onto the concave and convex airfoil walls shall be equal to 25 percent of the blade length from the platform to the blade tip. This distance shall include the airfoil to platform fillet radii.

FIGURE 3. Typical casting areas (type I).

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EXCLUDING BLADE  
FILLET RADII  
(CONCAVE & CONVEX)



NOTES:

- (1) Requirements of 5.1.1.3.4 apply to the illustrated shaded areas.
- (2) Leading and trailing edge radii shall be considered shaded areas.

FIGURE 4. Coating defects (type I).

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TABLE II. Visual and fluorescent penetrant acceptance limits (type II).

Type of indication	Casting area A	Casting area B	Casting area C
Unratable	0.005 inch or less	0.010 inch or less major dimension	0.010 inch or less major dimension
Pits, blowholes, bottomed porosity	Not allowed	0.030 inch maj. dim. 4 per side 0.060 inch at closest approach	0.030 inch maj. dim. 8 per side 0.060 inch at closest approach
Clusters of indications (Ratable plus unratable) Individual indication in cluster Indications per cluster Max. size Clusters per side Distance between clusters or single indications (Ratable or unratable)	Not allowed	0.010 inch major dim. 8 max. 0.10 inch major dim. 1 max. 0.060 inch min.	0.010 inch major dim. 8 max. 0.10 inch major dim. 2 max. 0.060 inch min.
Positive metal: Size Height Frequency Distance	0.030 inch major dim. 50% of major dim. up to 0.010 inch 4 per side 0.125 closest approach	0.030 inch major dim. 50% of major dim. up to 0.010 inch 4 per side 0.125 closest approach	0.030 inch major dim. 50% of major dim. up to 0.010 inch 8 per side 0.125 closest approach

## NOTES:

1. Clusters or single indications shall not be opposite or relatable.
2. Any ratable indication which breaks an edge shall be cause for rejection.
3. Where two surfaces of different classifications adjoin at a corner, the following conditions apply:
  - a. Casting areas B and C to casting area A surfaces: Allowable indications on casting area B or C surfaces must be 0.010 inch from the corner which adjoins a casting area A surface.
  - b. Casting area B or C surfaces: Allowable indications on a casting area B or C surface must be 0.005 inch from the corner which adjoins another casting area B or C surface.

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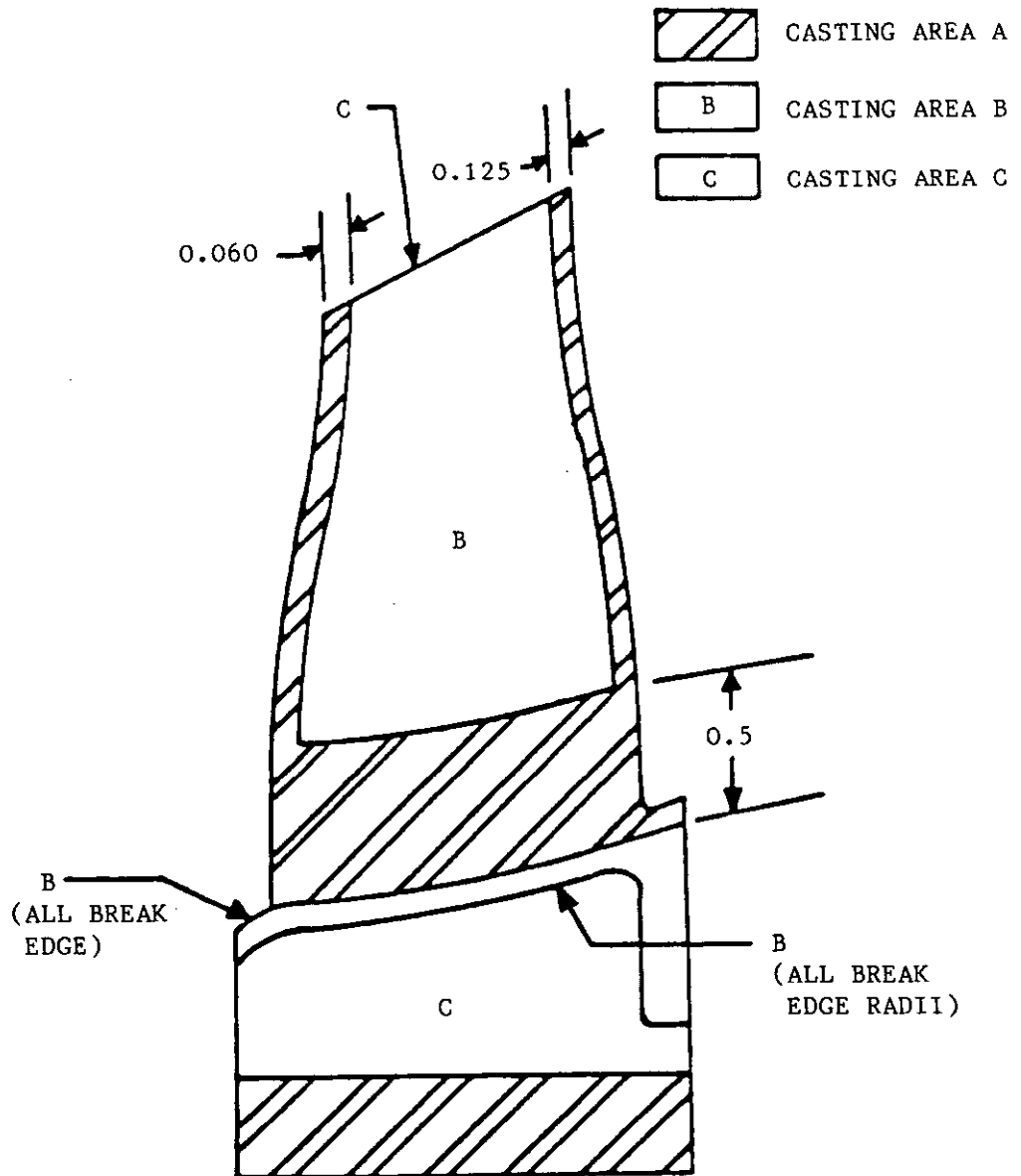


FIGURE 5. Typical casting areas (type II).

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TABLE III. Visual and fluorescent penetrant acceptance limits (type III).

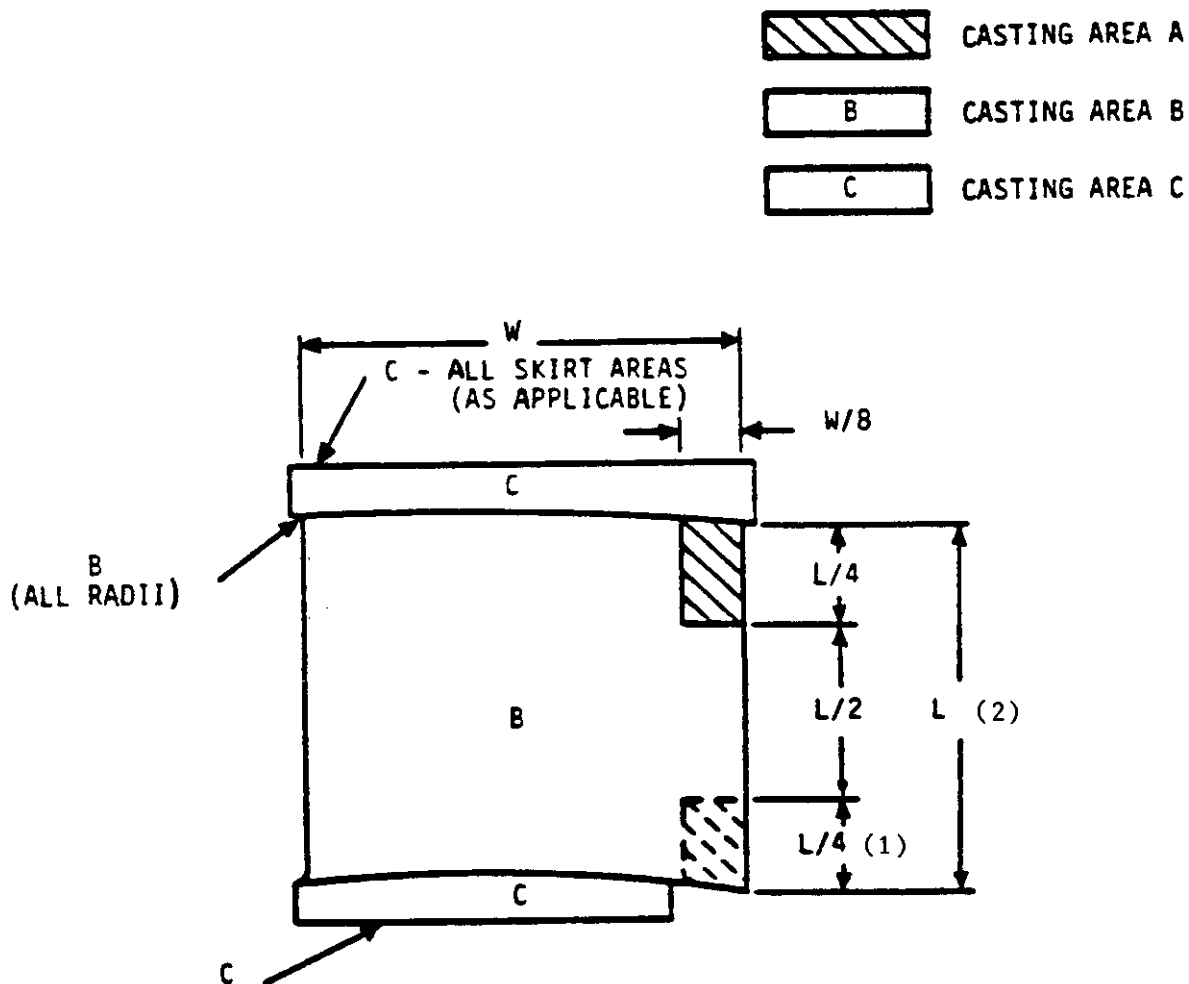
Type of indication	Casting area A	Casting area B	Casting area C
Unratable	0.010 inch or less	0.015 inch or less major dimension	0.015 inch or less major dimension
Pits, blowholes, bottomed porosity	Not allowed	0.045 inch major dim. 6 per side 0.060 inch at closest approach	0.045 inch major dim. 8 per side 0.060 inch at closest approach
Clusters of indications (Ratable plus unratable) Individual indication in cluster Indications per cluster Max. size Clusters per side Distance between clusters or single indications (Ratable or unratable)	Not allowed	0.015 inch major dim. 8 max. 0.10 inch major dim. 1 max.  0.060 inch min.	0.020 inch major dim. 8 max. 0.10 inch major dim. 2 max.  0.060 inch min.
Positive metal: Size Height Frequency Distance	0.030 inch major dim. 50% of major dim. up to 0.010 inch 4 per side 0.125 closest approach	0.030 inch major dim. 50% of major dim. up to 0.010 inch 4 per side 0.125 closest approach	0.030 inch major dim. 50% of major dim. up to 0.010 inch 8 per side 0.125 closest approach

## NOTES:

1. Clusters or single indications shall not be opposite or relatable.
2. Any ratable indications which breaks an edge shall be cause for rejection.
3. Where two surfaces of different classifications adjoin at a corner, the following conditions apply:
  - a. Casting areas B and C to casting area A surfaces: Allowable indications on casting area B or C surface must be 0.010 inch from the corner which adjoins a casting area A surface.
  - b. Coating area B or C surfaces: Allowable indications on a casting area B or C surface must be 0.005 inch from the corner which adjoins another casting area B or C surface.



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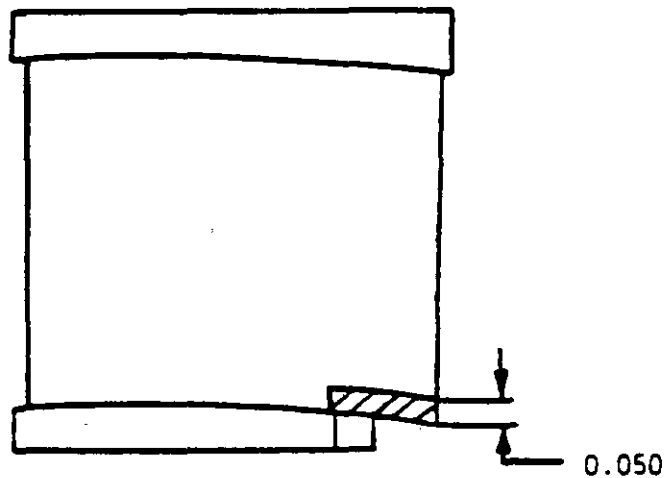


## NOTES:

- (1) This area shall be considered casting area A when full width of turbine vane enters inner shroud.
- (2) The trailing edge radius for the entire length of the airfoil shall be considered as casting area A.

FIGURE 6. Typical casting areas (type III).

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## NOTES:

- (1) All coated areas of the turbine vane shall conform to the surface coating requirements with the exception of the shaded area (from peg end to trailing edge) where chips shall be allowed on both the convex and concave airfoil surfaces.
- (2) Coating located on casting area C need not be inspected (reference FIGURE 6).
- (3) Leading and trailing edge radii shall be considered shaded areas.

FIGURE 7. Typical coating acceptance limits (type III).

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Custodian:  
Army - AT

Preparing activity:  
Army - AT

(Project 2835-A022)

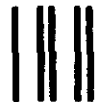
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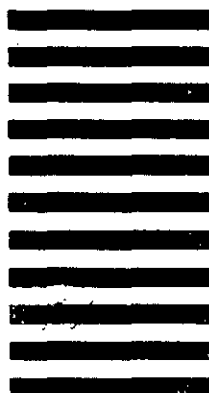
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**STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL***(See Instructions – Reverse Side)*

1. DOCUMENT NUMBER

2. DOCUMENT TITLE

3a. NAME OF SUBMITTING ORGANIZATION

4. TYPE OF ORGANIZATION *(Mark one)* VENDOR USER MANUFACTURER OTHER *(Specify):* \_\_\_\_\_b. ADDRESS *(Street, City, State, ZIP Code)*

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI) – Optional*b. WORK TELEPHONE NUMBER *(Include Area Code) – Optional*c. MAILING ADDRESS *(Street, City, State, ZIP Code) – Optional*8. DATE OF SUBMISSION *(YYMMDD)*