

**T-009 Inspection Limits and Repair**

<b>Subject:</b>	Inspection and Repair of Second Stage Turbine Nozzles
<b>EXTEX Part Numbers:</b>	A23031938, E23031938, A23031938-C, E23031938-C, 23031938AL, E6878426, E6878426-C
<b>Installations:</b>	Rolls-Royce (250-B17, B17B, B17C, B17D, B17E, B17F, B17F/1, B17F/2; 250-C18, C18A, C18B, C18C; 250-C20, C20B, C20C, C20F, C20J, C20R, C20R/1, C20R/2, C20R/4, C20S, C20W)
<b>Revision History:</b>	<p>NC – Dated 1/30/97 Original Issue.</p> <p>A – Dated 2/20/97 Updated format; added “FAA/DER procedure for airfoil repair”.</p> <p>B – Dated 11/28/97 Added Repair sources.</p> <p>C – Dated 6/08/98 Updated format, separated Inspect and Repair sections of manual, and removed Repair sources.</p> <p>D – Dated 3/16/99 Added Note 3 on page 2; changed compliance.</p> <p>E – Dated 6/26/03 Added min wall thickness on page 8. Incorporated tang weld repair to Note 4 on page 8. Added Metco 444 to PAR 5.0. Added AMS 2675 to PAR 6.0. Added braze spec and alloy spec to PAR 9.0. Added Repair Procedure 12 on page 10.</p> <p>F – Dated 3/16/05 Added E – Vane Fillet Cracks service limits and corrective actions.</p> <p>G – Dated 5/24/07 In Section 4.0, “see Section 6” was “see Section 5”. Added “Class C or better per AWS C3.6:1999” in Section 6. EFA changed to 5.02 - 5.06 for P/N's A23031938, E23031938, A23031938-C, E23031938-C and 5.02 - 5.12 for P/N's E6878426 and E6878426-C in Section 10.</p> <p>H – Dated 5/19/09 9.0 Added Alternative Braze Alloy AMS 4777.</p> <p>J – Dated 9/09/09 Updated EXTEX to TIMKEN.</p> <p>K – Dated 2/28/13 Added P/N 23031938AL. Indicated 250-C20C installation eligibility. Updated logo and format.</p> <p>L – Dated 2/02/16 Updated Timken to EXTEX Engineered Products.</p> <p>M – Dated 3/20/19 Deleted Note 3, added Note 4 to Service Limits with related edits to sections 1.0 and 9.0. Minor editorial and format changes.</p>
<b>Reason:</b>	To provide Supplemental Instruction for Continued Airworthiness (ICA)
<b>Description:</b>	This document provides the owner/operator with inspection and repair procedures for the Second Stage Turbine Nozzle. Any time the nozzle assembly is removed for engine overhaul or turbine wheel replacement, it can be inspected to EXTEX or OEM criteria. The inspection results determine if the component is serviceable in its current condition, if the component is repairable per this instruction or if the component should be replaced.
<b>Applicability:</b>	Rolls-Royce 250-B17, B17B, B17C, B17D, B17E, B17F, B17F/1, B17F/2; 250-C18, C18A, C18B, C18C, C20, C20B, C20C, C20F, C20J, C20R, C20R/1, C20R/2, C20R/4, C20S, C20W engines with A23031938, E23031938, A23031938-C, E23031938-C, 23031938AL, E6878426 or E6878426-C installed
<b>Accomplishment Instructions:</b>	<ol style="list-style-type: none"> <li>Clean part in an alkaline bath per standard practices using AMS 1536, AMS 1537, or equivalent.</li> <li>Perform Non-Destructive Testing (NDT) via Fluorescent Penetrant Inspection (FPI) per AMS 2647, Method D, Sensitivity Level 3 or better.</li> <li>Inspect part using the enclosed criteria.</li> </ol>
<b>Approval:</b>	This document is FAA approved.
<b>Notes:</b>	<p>Replaces Service Letter T-95-011 issued by Superior Turbine on May 24, 1994. Refer to Type Certificate Holder's published data for assembly, disassembly and engine operation.</p> <p>After first airfoil restoration, re-identify by adding R1 after Part No. (i.e. E23031938R1,) and R2 after second airfoil restoration. At this time EXTEX does not recommend more than two airfoil repair cycles to this part. If part number is followed by R2, airfoils cannot be repaired.</p> <p>Please contact your EXTEX representative with any questions.</p>

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Location / Condition	Service Limits	Corrective Action
<b>A - Airfoil Crack Indications</b>	Leading Edge: 0.25 inch maximum is acceptable.* Trailing Edge: 0.25 inch maximum is acceptable.* *Acceptance is contingent upon the following: 1) No L.E. & T.E. cracks lie in the same plane. 2) Multiple cracks are separated by at least 0.25 inch. 3) Adjacent cracks do not converge.	Airfoils may be repaired using attached procedure. Replace Nozzle Assembly when service limit cannot be met after repair.
<b>B - Damaged Airfoils</b>	L.E. & T.E. maximum material loss to a depth of 0.156 inch (4mm). Depth measured after blending.	Airfoils may be repaired using attached procedure. Replace Nozzle Assembly when service limit cannot be met after repair.
<b>C - Airfoil Negative Imperfections</b>	Negative imperfections in the first 0.25" of the airfoil L.E. & T.E. are subject to the crack criteria. Negative imperfections between L.E. & T.E. are acceptable up to an area of: 1/16" dia. X 1/2 section thickness.	Airfoils may be repaired using attached procedure. Replace Nozzle Assembly when service limit cannot be met after repair.
<b>D - Airfoil Positive Imperfections</b>	Positive imperfections in the first 0.25" of the airfoil L.E. & T.E. are to be no greater than 0.005", otherwise to 3/16" dia. X 0.010" height if smooth and adherent, and part line evidence to 0.015" height.	Airfoils may be repaired using attached procedure. Replace Nozzle Assembly when service limit cannot be met after repair.
<b>E - Vane Fillet Cracks</b>	At Inner Band: 0.25 inch maximum from Leading or Trailing edge. At Outer Band: 0.25 inch maximum from Leading or Trailing edge. <b>NOTE:</b> Length specified is for cracks along the airfoil measured parallel to the adjacent band. Two or more cracks are acceptable provided neither crack propagates toward another.	Airfoils may be repaired using attached procedure. Replace Nozzle Assembly when service limit cannot be met after repair.
<b>F - Outer Band Cracks</b>	See Repair Section.	Repair using attached procedure. Replace Nozzle Assembly when service limit cannot be met after repair.
<b>G - Inner Band Crack</b>	See Repair Section.	Repair using attached procedure. Replace Nozzle Assembly when service limit cannot be met after repair.
<b>H - Diaphragm Crack</b>	Cracks are not acceptable - See Note 4.	Install new diaphragm sub-assembly.
<b>I - Inner Seal Bore Wear/Grooving</b>	Polish to remove burrs and sharp edges. I.D.: 1.823 - 1.825 inch diameter. Depth of Grooves: 0.012 inch maximum. Concentricity: 0.003 inch maximum TIR.	Re-plate or metallize per attached procedures - See Figures 2 & 3. Minimum sheet metal wall thickness: 0.020 inch. Replace sheet metal if minimum wall thickness requirement is violated.
<b>J - #1 Blade Tip Path</b>	Maximum Inner Diameter of blade tip path: 6.221 inch diameter	See Repair Section.

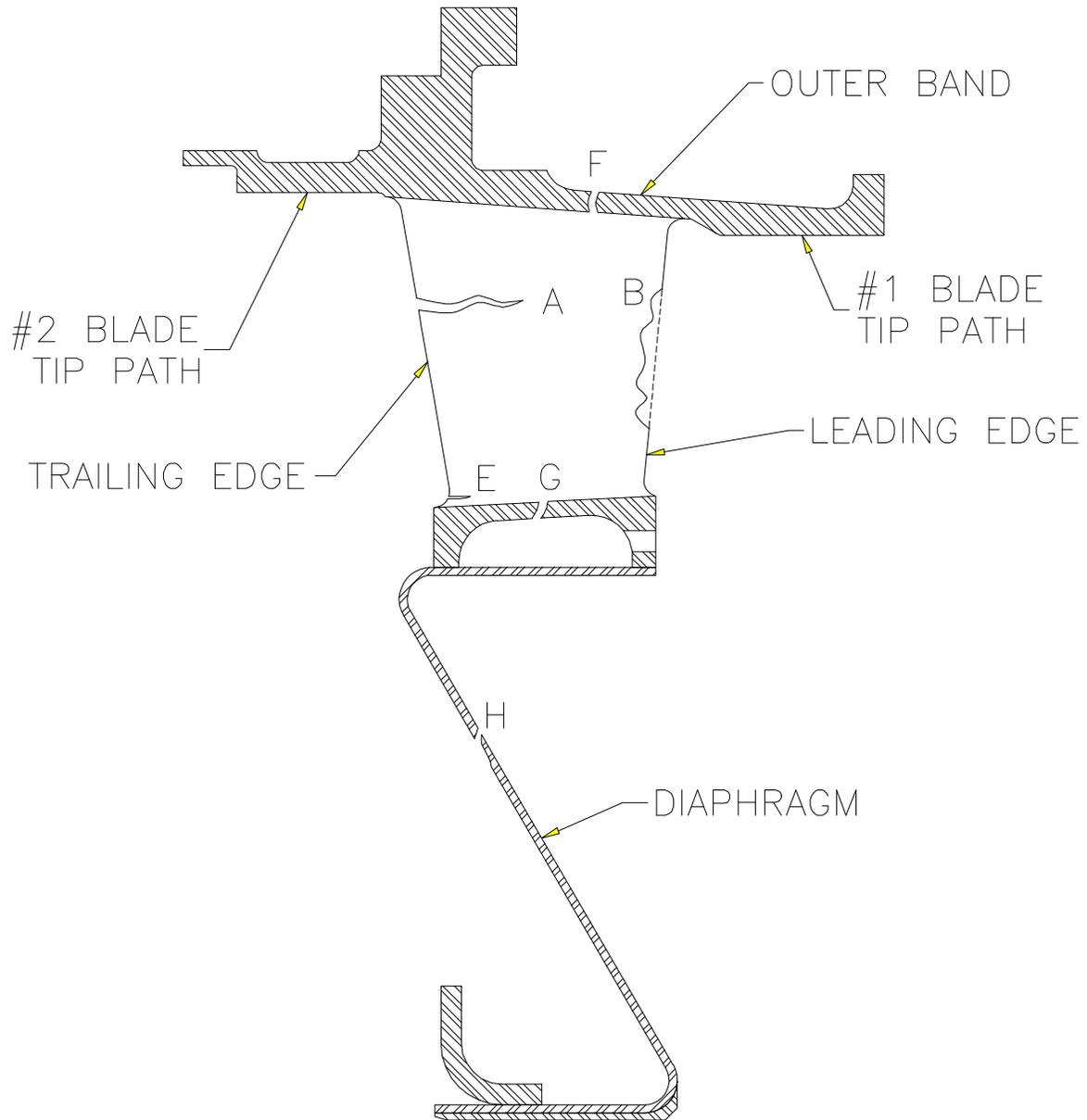
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Location / Condition	Service Limits	Corrective Action
<b>K - #2 Blade Tip Path</b>	Maximum Inner Diameter of blade tip path: 250-C20B, C20C, C20F, C20J, C20S, C20W: 6.435 inch diameter.  250-C20: 6.441 inch diameter.	See Repair Section.
<b>L - Machined Surfaces, Visual Damage</b>	Imperfections must not exceed 0.120 inch diameter and 0.010 inch depth.	Repair using attached procedure. Replace Nozzle Assembly when service limit cannot be met after repair.

**Notes:**

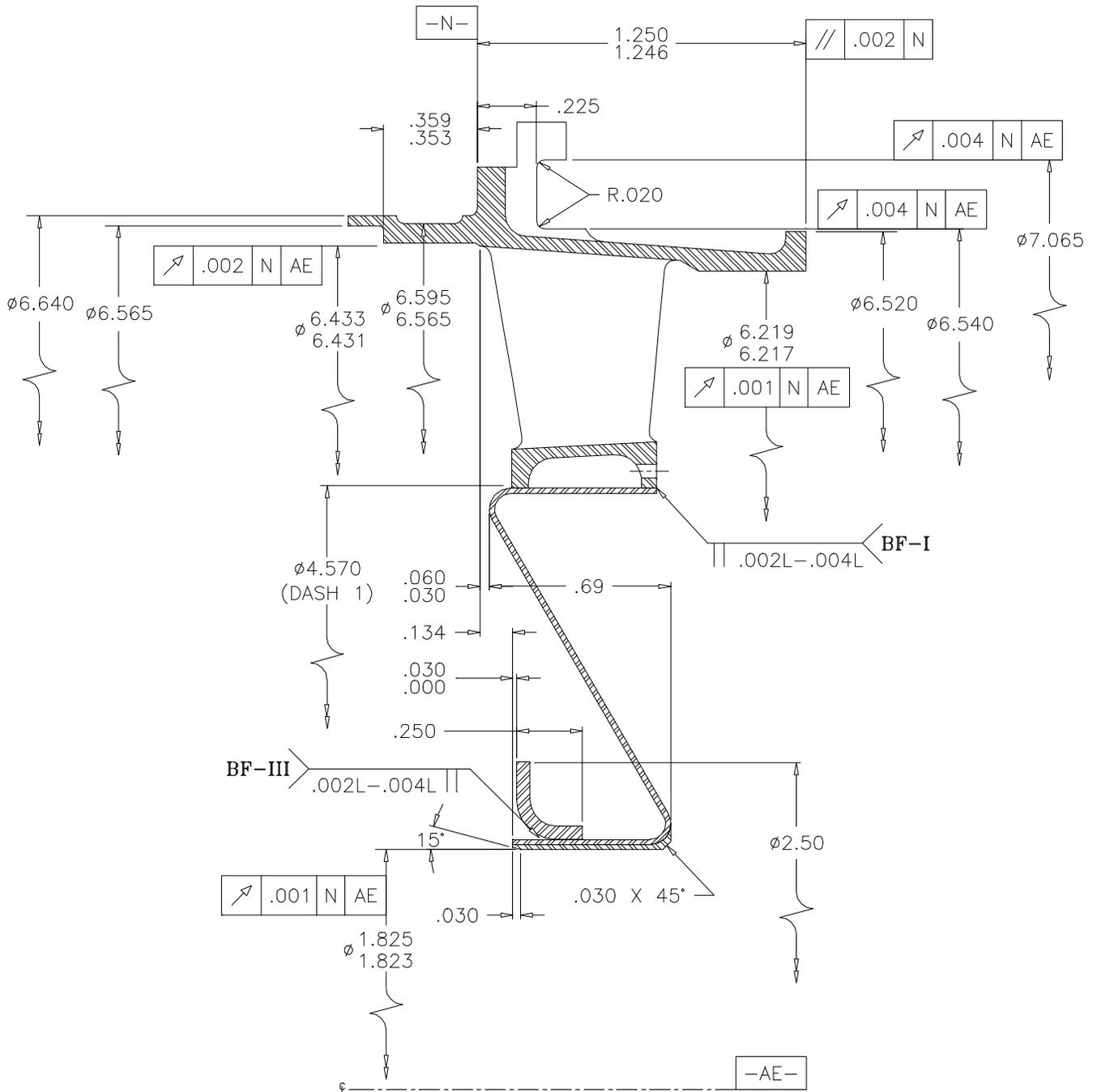
1. Blending to remove L.E. and/or T.E. damage may affect airflow.
2. Blend and polish acceptable vane edge damage in a radial direction using a fine file or 320 grit abrasive paper. Optimum blend should produce scallops with a 2:1 width to depth ratio. Maintain a smooth blend with the basic airfoil. Trailing edge radius after blend to be greater than 0.005 inch.
3. Deleted.
4. Replace diaphragm at each HMI even if no diaphragm cracks are present.

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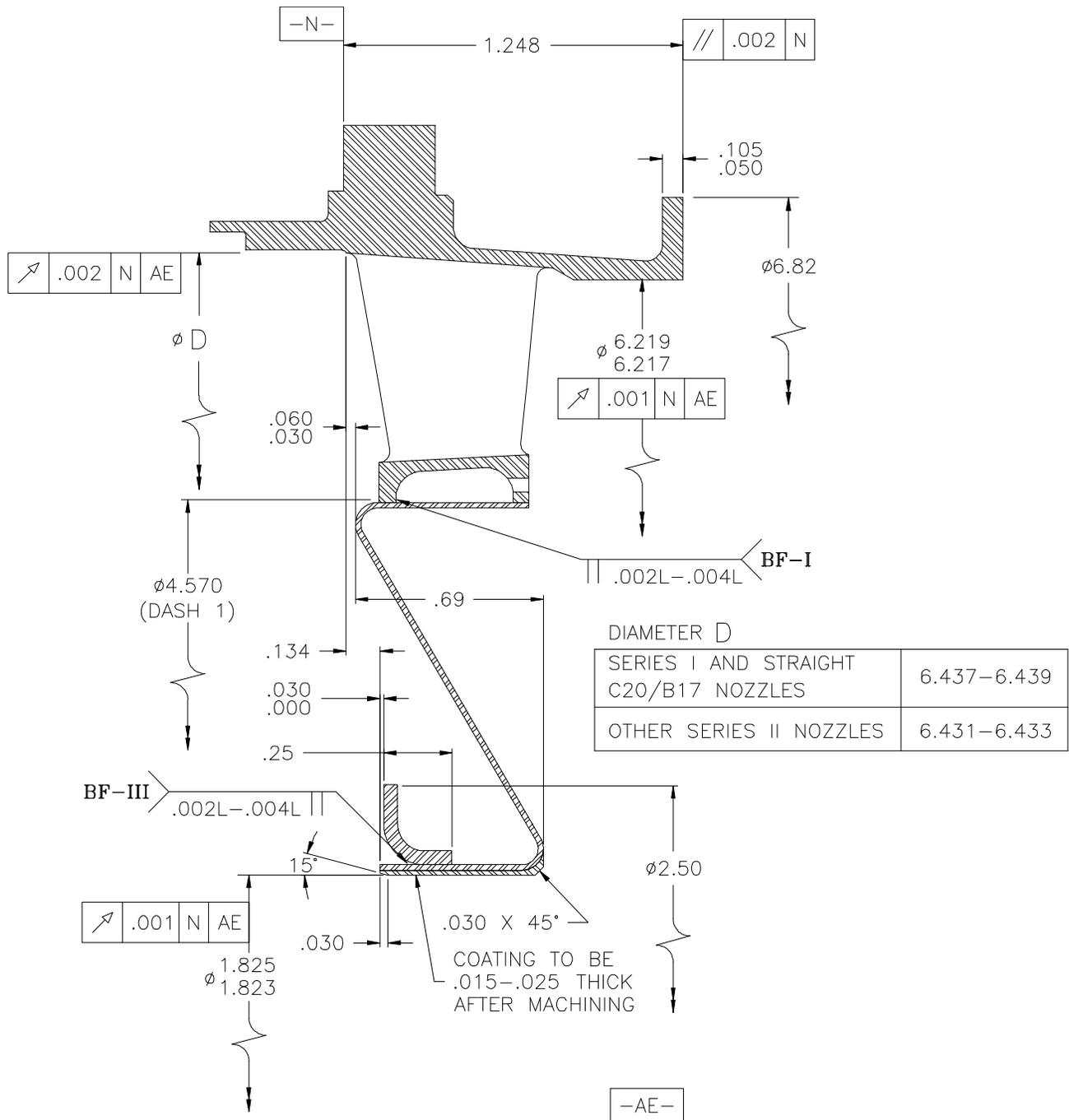
**FIGURE 1**

**T-009 Inspection Limits and Repair**



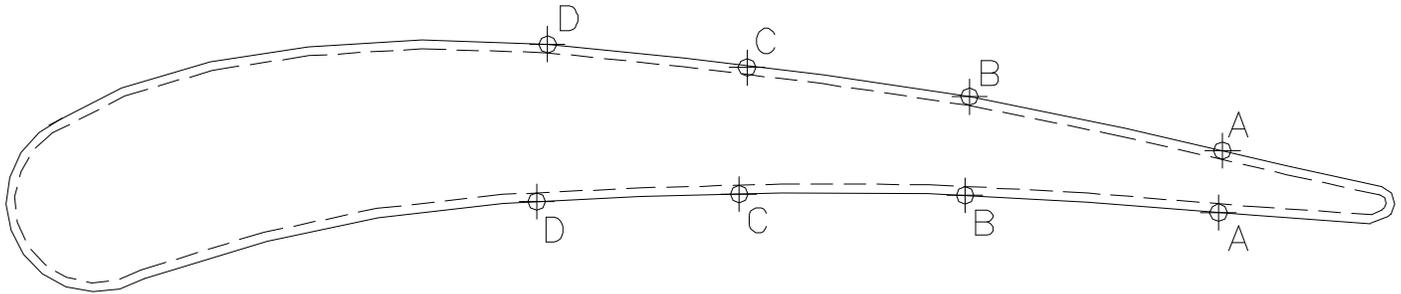
**FIGURE 2: A23031938, E23031938, A23031938-C, E23031938-C & 23031938AL**

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**FIGURE 3: E6878426 & E6878426-C**

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**TYPICAL AIRFOIL CROSS-SECTION**

Location	Distance from Trailing Edge [inches (mm)] - Measured along airfoil surface	Airfoil Minimum Thickness [inches (mm)] - Thickness in fillet radius not measured
A	0.125 (3.17)	0.022 (0.56)
B	0.250 (6.35)	0.034 (0.86)
C	0.375 (9.52)	0.048 (1.22)
D	0.500 (12.70)	0.068 (1.73)

**FIGURE 4**

**Repair Procedures**

Instructions are provided to strip coating from gas path surfaces; weld repair of airfoil leading and trailing edges; braze repair of airfoil and fillet cracks; weld or braze repair of inner and outer band cracks, airflow adjustment; and replacement of diaphragm and support plate. Figure 1 depicts key features of the subject nozzles.

**1.0 Diaphragm:** Remove diaphragm from vane ring by de-brazing or machining. Replace with new diaphragm and ring.

**2.0 Vane Ring Coating:** For part numbers without "-C", skip to Section 3.0. Parts marked with "-C" (e.g. E23031938-C) have an Aluminide coated gas path. The coating must be removed before repairing. Strip coating from gas path surfaces per an appropriate acid strip cycle. Verify complete coating removal via heat tinting. Repeat acid stripping and heat tinting until nozzle is free of coating.

*Recommended Acid Strip Cycle:*

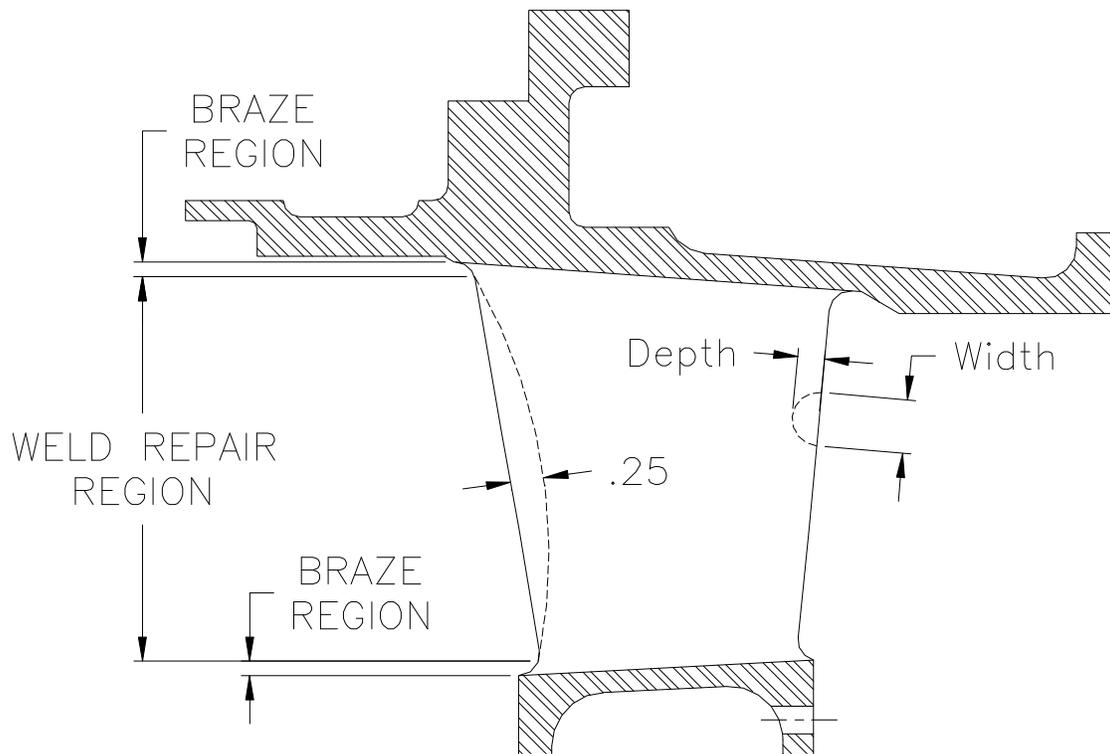
- Insure that part is free of grease and contamination.
- Grit blast coated surfaces with 220 grit aluminum oxide at 60 psi max.
- Soak in nitric-phosphoric acid at 180°F for 10 minutes.
- Rinse in clean water and neutralize.
- Grit blast and repeat acid and rinse/neutralize cycles until visible evidence of coating is gone.

*Recommended Heat Tint Cycle:*

- Grit blast component with 220 grit aluminum oxide at 60 psi max.
- Place in air furnace at 1100°F for 30 minutes, then remove.
- Inspect for residual coating. Coated surfaces will appear gold while base metal will appear blue.

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**3.0 Weld Repair of Airfoils:** Welding can be used to replace missing material at airfoil edges or it can be used to repair damage such as cracks. Blend areas to be welded with coated abrasives and/or carbide burr. Remove all sharp edges, cracks, and surface contamination; such as oxides (from engine service). Material removal should not exceed a depth of .250" from LE or TE of airfoil. Material removal should appear as a gradual arc with a width to depth ratio of 2:1, see Figure 5. Material removal and welding should not be attempted within .050 of fillet between airfoils and inner/outer bands. Fillet cracks should be repaired via furnace braze, see Section 5.



**FIGURE 5**

Just prior to welding, all surfaces to be welded should be retouched with a carbide burr. Preheat part to 700°F (371°C) before welding and maintain an inter-pass temperature of 700°F (371°C). Weld build-up as necessary via Gas Tungsten Arc (GTA) welding, also known as Tungsten Inert Gas (TIG) welding. It is recommended to use .030" to .045" diameter weld filler. Weld filler may be Inconel 625 or Inconel 738 (base alloy), see note below. Minimize heat input to avoid cracking.

Note: Inconel 625 (also known as IN-625) is a widely used nickel-based weld filler alloy due to its excellent ductility. Its high ductility helps to avoid Heat Affected Zone (HAZ) cracking during or just after welding. However, IN-625 does not match the high temperature strength of base alloy Inconel 738 (also known as IN-738). While IN-625 weld repairs will provide adequate life extension for repaired nozzles, welding with base alloy IN-738 will more closely meet new part life expectations. IN-738 weld filler is commercially available; however, it should be noted that welding with IN-738 will be more prone to cracking than welding with IN-625. More skill is required to successfully weld with IN-738 than welding with IN-625.

Heat-treat within 12 hours of welding at 1000°F ± 25°F (538°C ± 14°C) for 2 hours in inert or slightly reducing atmosphere.

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Visually inspect welds for gross porosity and/or cracking. Note that weld bead will appear rough and may be mistaken for defects. Questionable areas can be hand finished to verify presence of defects. Restore vane contour, LE radius and TE radius via hand finishing (blending). Use coated abrasives or carbide burrs as necessary.

Fluorescent Penetrant Inspect (FPI) welded areas per AMS 2647, Method D, Sensitivity Level 3. No linear indications are allowed. Note that indications less than .015" are considered un-interpretable and can be ignored. Rounded indications (i.e. porosity) up to .030" Dia. are acceptable. Multiple round indications must be separated by at least twice the diameter of the larger indication.

EFA of repaired nozzles must be checked and modified if not within acceptable range. See Section 10. Repaired airfoils must meet minimum dimensions shown in Figure 4.

**4.0 Weld Repair of Inner / Outer Bands and Tangs:** Welding can be used to repair cracks that are too wide for furnace braze & to restore tang width. (Furnace braze repairs are preferred if cracks are less than .020" wide.) Welding limits are as follows:

### *Outer Band.*

- Up to 4 cracks on forward edge and 4 cracks on aft edge extending axially into band. Each crack must be less than .500" long.
- If two cracks extend from opposite edges towards each other, then the sum (of the length) of both cracks must be less than .500".
- Missing material from intersecting cracks can be repaired within .250" of edge.
- Circumferential cracks should be furnace brazed, see Section 6.

### *Inner Band.*

- Up to 4 cracks on forward edge and 4 cracks on aft edge extending axially into band, each crack must be less than .200" from edge.
- Missing material from intersecting cracks can be repaired within .100" of edge.

### *Tangs.*

- Finish machine tang to .374/.375 wide after welding.

Blend areas to be welded with coated abrasives and/or carbide burr. Remove all sharp edges, cracks and surface contamination such as oxides (from engine service). Material removal should not exceed limits described above. Material removal should appear as a gradual arc with a width to depth ratio of 2:1. Just prior to welding, all surfaces to be welded should be retouched with a carbide burr. Preheat part to 700°F (371°C) before welding and maintain an interpass temperature of 700°F (371°C). Weld build-up as necessary via Gas Tungsten Arc (GTA) welding, also known as Tungsten Inert Gas (TIG) welding. It is recommended to use .030" to .045" diameter weld filler. Weld filler may be Inconel 625 or Inconel 738 (base alloy), see note in Section 3. Minimize heat input to avoid cracking.

**5.0 Blade Tip Paths:** If previously sprayed, remove metal spray from 1<sup>st</sup> stage blade path. Prepare nozzle forward flange for welding by mechanically removing oxidation. Degrease part. Build up leading edge face by welding per GTAW Class II using .035 in. dia. Hastelloy (AMS 5838) rod. Welding should be accomplished using a 1/16 in. dia. tungsten rod with the welding current set to 30 AMPS. A low heat weld pass should be made around the entire forward flange face. If additional buildup is required additional passes may be made being careful to minimize heat input. Blend O.D. of the weld bead to restore the outer contour diameter. Machine the leading edge face dimension relative to Datum -N- (Figure 2 or 3). Machine #1 Blade Tip Path to a maximum diameter of 6.239 inches. Machine #2 Blade Tip Path to a maximum diameter of 6.459 inches. Minimum wall after machining is .045. Blade Tip Paths can be restored using the following procedure:

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Blast machined surface with aluminum oxide per the following procedure. Clean localized area to be blasted. Blast with aluminum oxide grit under 25-115 psi pressure against the surfaces to be blasted. Remove all loose particles from grit blasted surfaces.

Degrease the part. Mask the part-to prevent overspray of adjacent surfaces. Brush surface to be metallized with lacquer thinner or methyl ethyl ketone. Metallize per Plasma Spray Coating Nickel-Aluminum Composite (METCO 450, 443, 444 or AMDRY 960) or Nickel Plate per MIL-C-26074. Remove masking carefully and clean off overspray. Re-machine to print and inspect dimensionally. If Nickel Plated, FPI per AMS 2647, Method D, Sensitivity Level 3. Accept per Par 3.0 FPI weld repair. Reclassification of nozzle area is required.

**6.0 Furnace Braze Repair of Vane Ring:** Furnace brazing AMS 2675 (class C or better per AWS C3.6:1999) is an excellent method to repair cracks or to fill shallow voids on the vane ring features such as airfoils and inner/outer bands. Furnace brazing can fill cracks up to .020" wide and creates less distortion than welding. A high temperature braze must be used to repair the vane ring in order to ensure that the braze alloy does not remelt when rejoining the vane ring to the diaphragm assembly.

Note: The diaphragm assembly is brazed into place with AMS 4777 braze alloy. With a Solidus-Liquidus range of 1780°F-1830°F, AMS 4777 would be brazed at approx. 1830°F to 1850°F. EXTEX recommends that the braze alloy used for vane ring repair have a Solidus temperature above 1950°F. Two examples are AMS 4782 with a Solidus temperature of 1975°F and AMS 4785 with a Solidus temperature of 2075°F. There are many other braze alloys commercially available that meet this requirement.

Similar to welding, surfaces to be braze repaired must be cleaned. Cracks cannot be cleaned via abrasive media or carbide burrs because the crack would be opened beyond the bridging capability of the braze alloy. Instead, cracks should be cleaned in a reducing atmosphere. Examples of reducing atmospheres include heating the vane ring in hydrogen atmosphere up to 2100°F in some kind of furnace or retort. An alternate and better method, known as Fluoride Ion Cleaning (FIC), places the part to be brazed in an atmosphere of hydrogen fluoride at very high temperature (i.e. 2050°F - 2150°F).

All brazing must be performed in a reliable vacuum furnace, which is capable of controlling temperature to within  $\pm 10^\circ\text{F}$ . This measure of control is necessary to insure melting of the braze alloy while avoiding melting of the base metal IN-738. Braze temperature and time cycle will be controlled by the braze alloy employed.

Braze filler can be applied via a simple syringe or can consist of precut preforms. EXTEX recommends that an appropriate "stop off" be used to contain braze to those areas being repaired. Following brazing, hand finishing should be employed to restore part to its original dimensions and features.

**7.0 Heat Treatment:** As part of the repair, the vane ring must be solution heat treated to 2050°F for 2 hours and then precipitation hardened (strengthened) at 1550°F for 24 hours.

**8.0 Center Bore Stationary Lab Seal Surface:** This surface can be repaired using either of the two following methods:

**8.1 Nickel Plating:** Machine out old plating down to base material (Diameter 1.857-1.863). Optional to FPI per AMS 2647, Method D, Sensitivity Level 3. Re-plate per AMS 2424 low stressed deposit nickel plating. Machine new plating to Dia. 1.819-1.822 inches. This leaves .002 - .005 inch stock for finish grinding. Stress relieve part at  $1650^\circ \pm 25^\circ\text{F}$  ( $899^\circ \pm 14^\circ\text{C}$ ) for one hour in a vacuum or slightly reduced atmosphere. After stress relieving, finish grind the seal to reduce plating thickness to 0.015-0.025 inches. FPI per AMS 2647, Method D, Sensitivity Level 3. Accept per Par 3.0 FPI weld repair.

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**8.2 Metallizing:** Machine the I.D. of the Center Bore. Do not exceed maximum metal removal limit (Minimum sheet metal wall thickness 0.020 inch). After machining, FPI the part prior to metallizing per AMS 2647, Method D, Sensitivity Level 3. Blast machined surface with aluminum oxide. Degrease the part. Mask the part to prevent overspray of adjacent surfaces. Brush surface to be metallized with lacquer thinner or methyl ethyl ketone. Metallize per Nickel-Chromium-Boron Nitride Composite, Plasma Flame Deposition using METCO 301NS. Remove masking carefully and clean off overspray. Finish machine the Center Bore to 1.823-1.825 inches by single point turning leaving a thickness of 0.015-0.025 inch of Metco 301. After machining dimensionally inspect per Figure 2 or 3, as appropriate.

**9.0 Installation of Diaphragm:** Install a new diaphragm and ring by brazing. Be certain to prevent braze material from entering axial holes in the inner band of the vane ring. Location of the diaphragm relative to the vane ring is presented in Figures 2 & 3. Braze per AMS 2675 using AMS 4782 or AMS 4785 or AMS 4777 alloy.

**10.0 EFA Measurement (diaphragm assembly installed):** Repaired nozzle assemblies must be airflow tested after repair. The acceptable EFA range for the Second Stage Nozzle Assembly is 5.02-5.06 square inches for P/N's A23031938, E23031938, A23031938-C, E23031938-C, 23031938AL and 5.02-5.12 square inches for P/N's E6878426 and E6878426-C. Parts that do not meet the EFA limits can be adjusted by performing one of the following approved methods:

*Shot Peen Adjustment (Open or Close EFA)*

- Shot peening the trailing edge of the nozzle vanes will slightly change the geometry of each airfoil and thus will change the EFA of the turbine nozzle.
- Cast steel shot size 230 or 190 must be used. To ensure uniform peening of each blade, a turn-table must be used to rotate the part relative to the shot-peen nozzle.
- The shot-peen nozzle should be about 3 to 5 inches from the turbine nozzle vanes and the angle of incidence as close to 90 degrees as is practical.

*Vane Trailing Edge Modification. (Open EFA)*

- To increase EFA substantially (i.e. 2% - 3%), a high-speed rotary tool may be used to remove material from the trailing edge of each vane on the turbine nozzle.
- A maximum of 0.03" may be removed from the original length of each vane. Each vane shall have an equal amount of material removed and must have the trailing edge blended to its original radius.
- Blended areas shall be uniform in appearance and have smooth continuous transitions to non-blended areas.

**11.0 Part Marking:** If part number is followed by "-C", obliterate "-C" or cross out with an "X". Mark "EFA" and new Effective Flow Area.

**12.0 Metallizing for Dimensional Restoration.** Metallize Wheel Shrouds (blade tip Paths), forward flange, and surface -N-. Machine the surface or dimension to be repaired as necessary. Remove sufficient material to provide 0.005 minimum coating after machining. Do not exceed maximum metal removal limits. After machining, FPI the part prior to metallizing. Blast machine surface with aluminum oxide. Degrease the part. Mask the part to prevent overspray of adjacent surfaces. Brush surface to be metallized with lacquer thinner or methyl ethyl ketone. Metallize per METCO 450, 443, 444 or AMDRY 960. Remove masking carefully and clean off overspray. Re-machine to Figure 3 and inspect.