

T-066 Inspection Limits and Repair

First Stage Turbine Nozzle

Engine Application(s):	Allison 250-B17, B17B, B17C, B17D, B17E, B17F, B17F/1, B17F/2, 250-C20, C20B, C20C, C20F, C20J, C20R, C20R/1, C20R/2, C20R/4, C20S, C20W.
Compliance:	Any time the nozzle assembly is removed for engine overhaul, it should be inspected to Extex criteria. The inspection will determine if the component is serviceable in its current condition, if it the component is repairable per this instruction or if the component should be replaced.
Notes:	
Revisions:	N/C Dated: 01/11/02 Initial Release. A Dated: 08/27/09 Updated EXTEX to TIMKEN. B Dated: 2/04/16 Updated Timken to EXTEX Engineered Products.

Inspection Procedures

- 1.0 Clean part in an alkaline bath per standard practices using AMS 1536, AMS 1537, or equivalent.
- 2.0 Perform Non-Destructive Testing (NDT) via Fluorescent Penetrant Inspection (FPI) per AMS 2647, Method D, Sensitivity Level 3 or equivalent.
- 3.0 Inspect part using the following criteria.

T-066 Inspection Limits and Repair

Location / Condition	Service Limits	Corrective Action
A – Airfoil Crack Indications	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. Install new or serviceable Nozzle Assembly per approved procedure if Service Limit cannot be met.
B – Damaged Airfoils	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. Blend damaged surface(s) reference notes 1 & 2. Replace Nozzle Assembly when service limit cannot be met.
C-Airfoil Negative Imperfections	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 ½ section thickness.	Airfoils may be repaired using attached procedure. Install new or serviceable nozzle assembly.
D-Airfoil Positive Imperfections	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. Install new or serviceable nozzle assembly.
E – Vane Fillet Cracks	At Inner Band: 0.25 inch maximum from Leading or Trailing edge. At Outer Band: 0.25 inch maximum from Leading or Trailing edge. NOTE: 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.
F – Outer Band Cracks	See Repair Section.	Repair using attached procedure. Install new or serviceable Nozzle if Service Limit cannot be met.
G – Inner Band Crack	See Repair Section.	Repair using attached procedure. Replace Nozzle Assembly when service limit cannot be met.
H – Diaphragm Crack	Cracks are not acceptable.	Install new diaphragm subassembly.

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.**

T-066 Inspection Limits and Repair

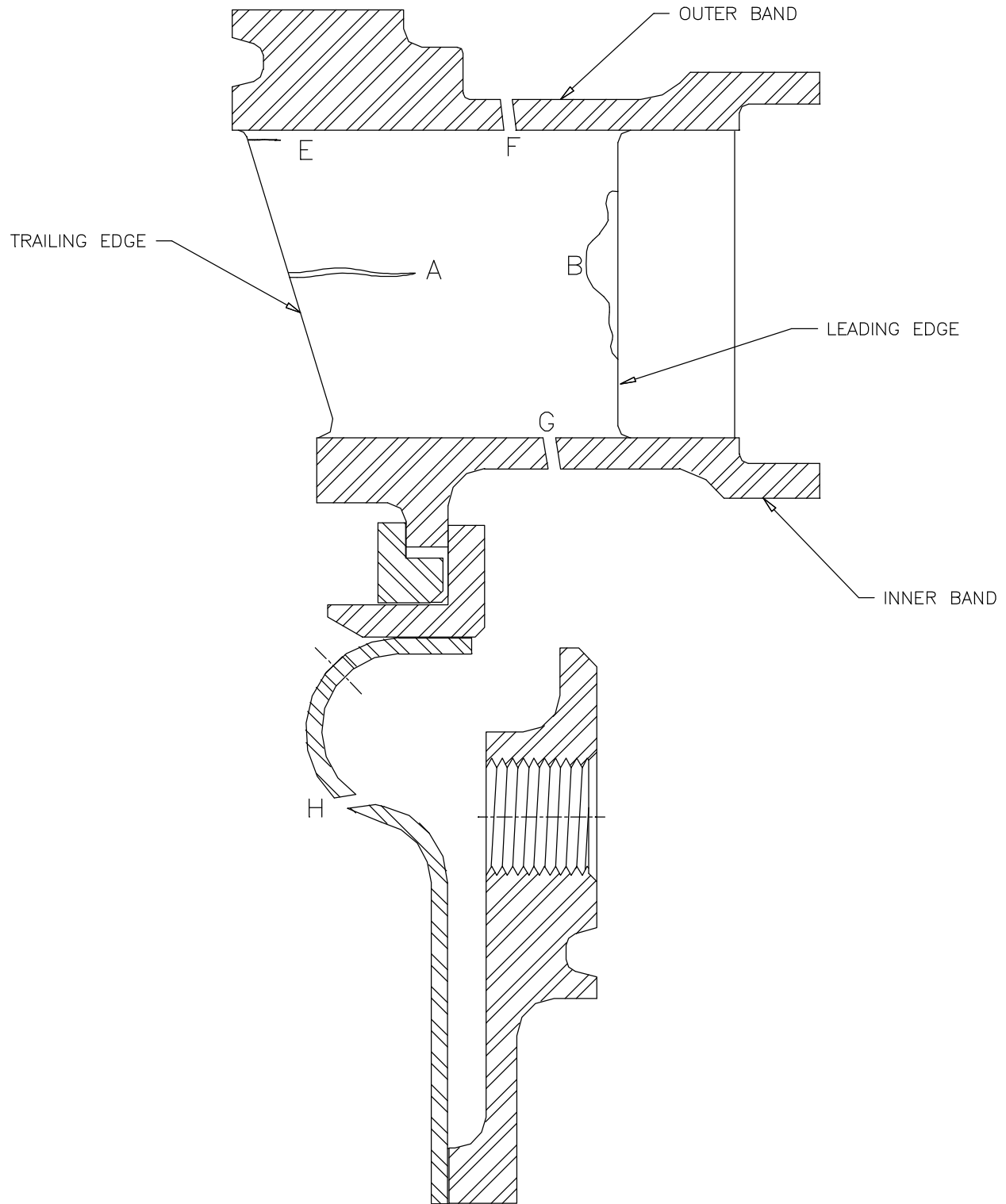


FIGURE 1

T-066 Inspection Limits and Repair

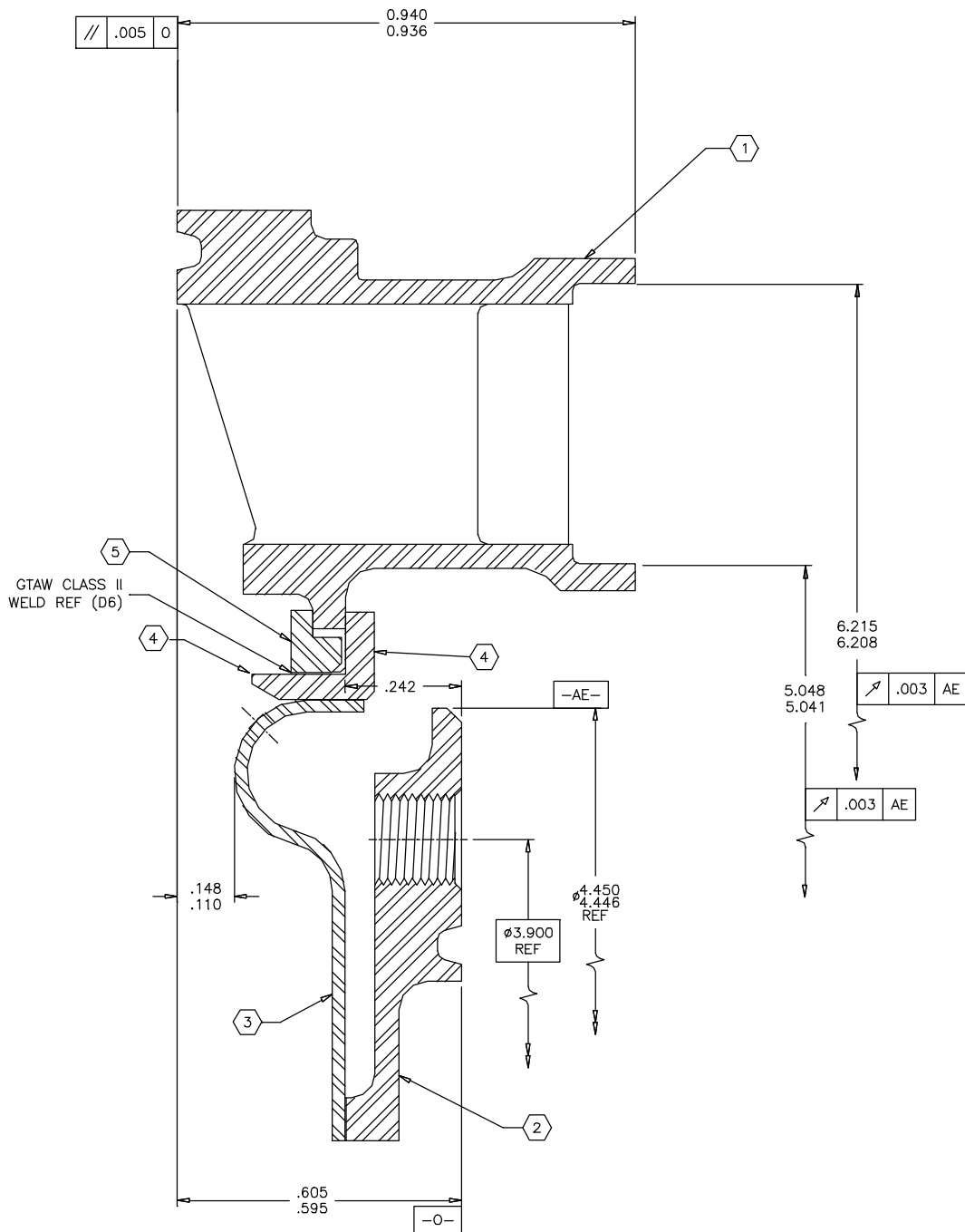


FIGURE 2

T-066 Inspection Limits and Repair

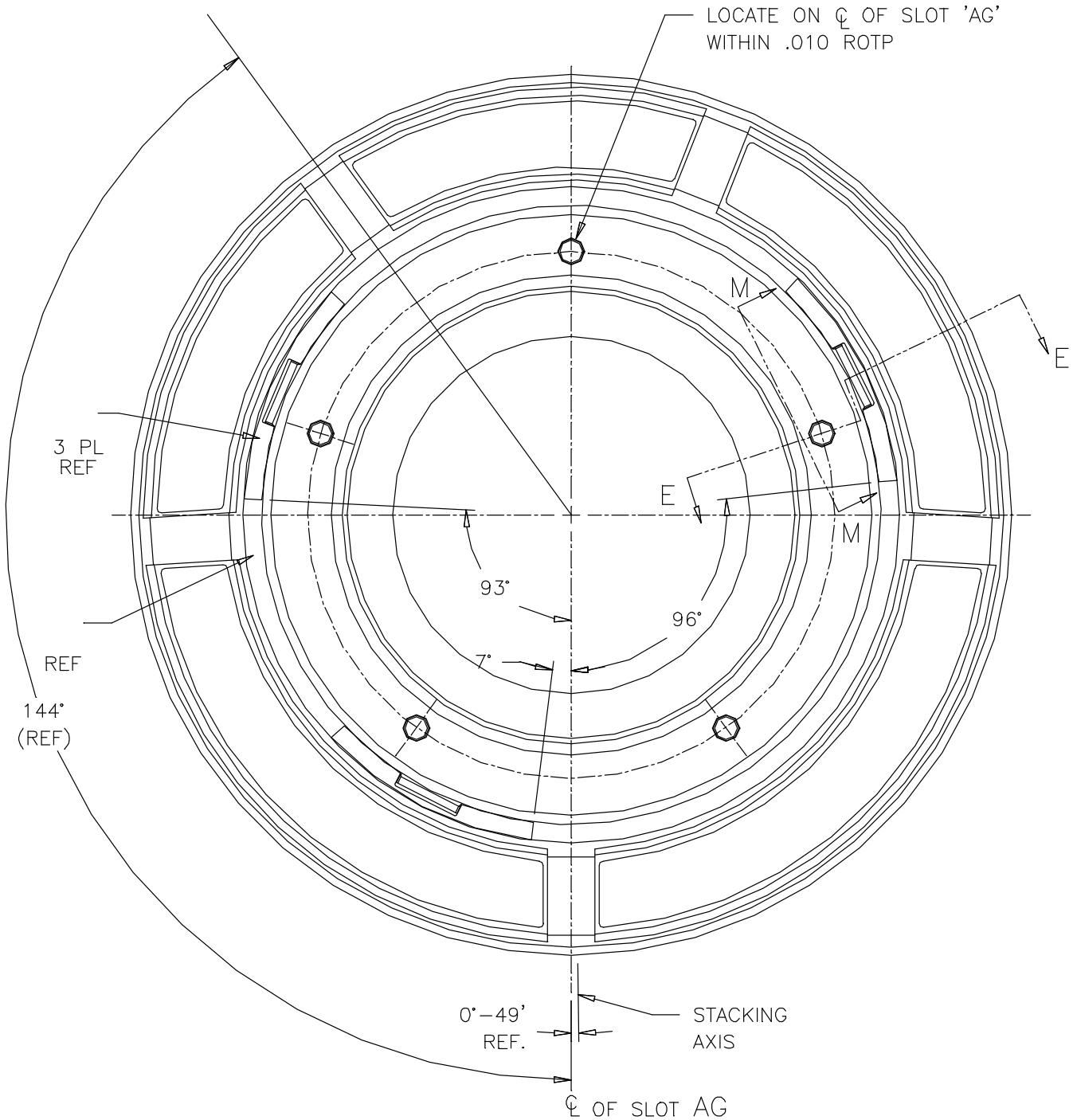


FIGURE 3

T-066 Inspection Limits and Repair

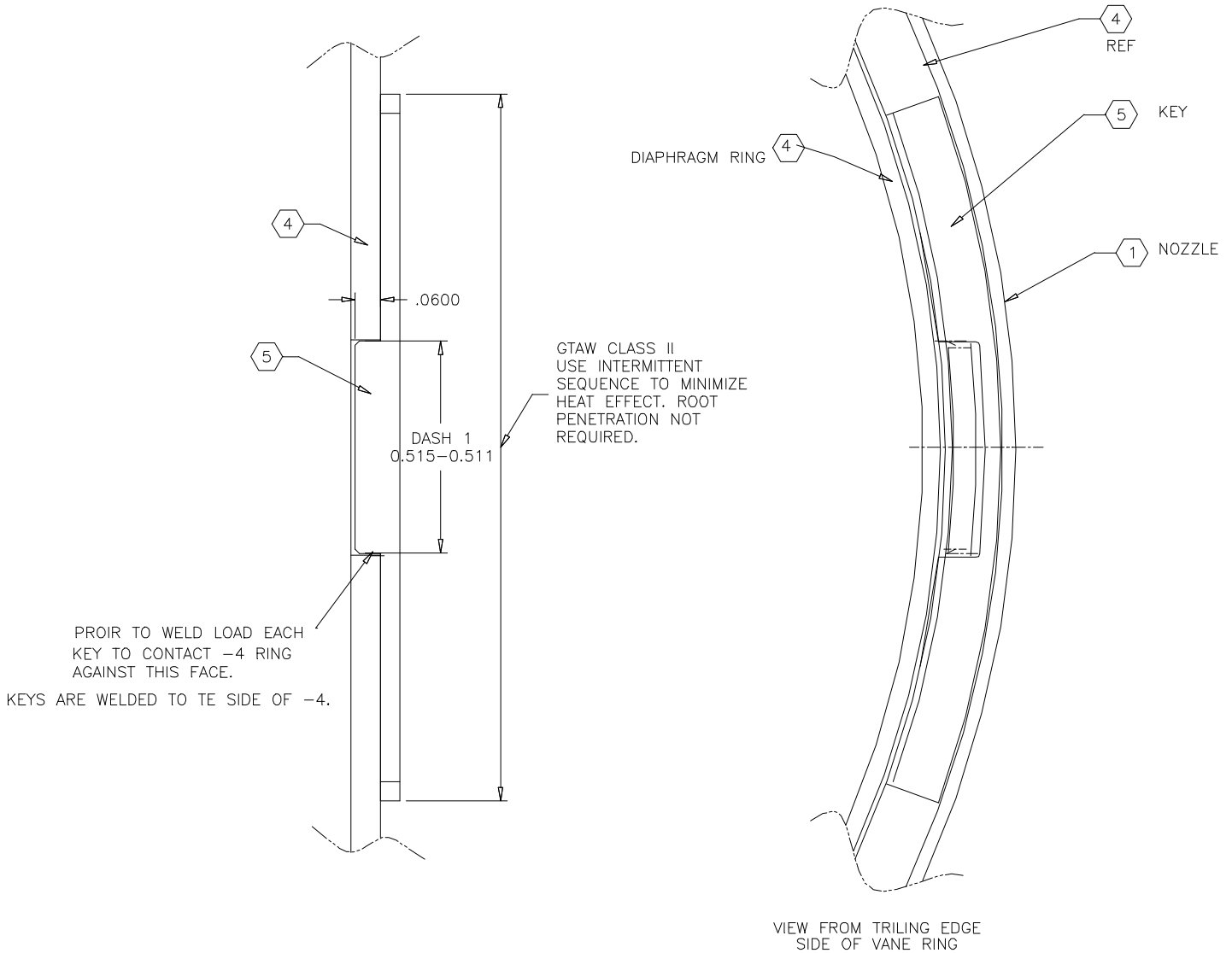
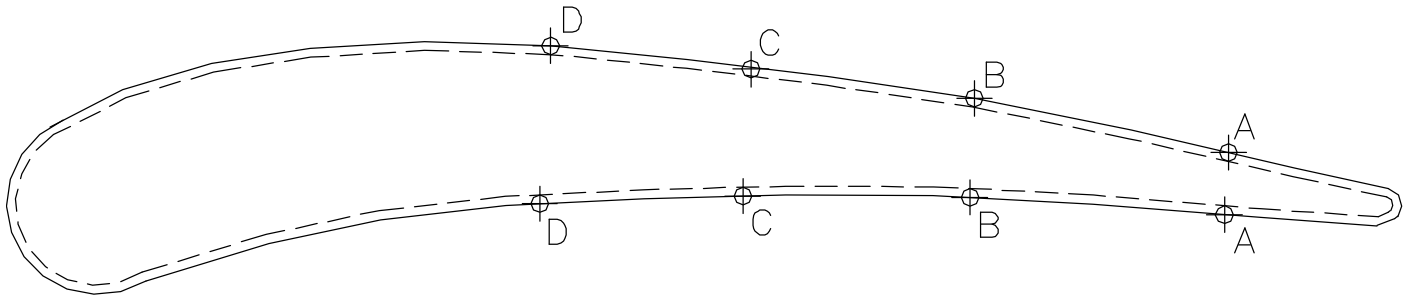


FIGURE 4

T-066 Inspection Limits and Repair



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)	0.021 (0.53)
B	0.250 (6.35)	0.034 (0.86)
C	0.375 (9.52)	0.047 (1.19)
D	0.500 (12.70)	0.067 (1.70)

FIGURE 5

Repair Procedures

Instructions are provided for strip and recoating of 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.

NOTE: The following instructions for weld or braze repair apply to nozzle vane rings manufactured from MAR-M-247 alloy. Vane rings, which do not meet the return to service criteria, and require repair/overhaul beyond blending and strip/re-coat, may be repaired to this procedure. A known source for weld repair or other repair options is:

Chromalloy Arizona (602) 272-1768

1.0 Diaphragm Subassembly: Grind key welds in order to free diaphragm subassembly from vane ring casting. Take care during grinding to avoid excessive gouging into diaphragm and ring. Remove diaphragm assembly from vane ring and set aside for repair or replacement. The diaphragm assembly has a slip fit to the vane ring.

2.0 Vane Ring Coating: Strip coating from gas path aluminide or platinum-aluminide 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.

T-066 Inspection Limits and Repair

Recommended Acid Strip Cycle:

- Insure that part is free of grease and contamination.
- Grit blast coated surfaces with 220 grit aluminum oxide at 60 max. psi.
- Soak in nitric-phosphoric acid at 180°F for 10-30 minutes.
- Rinse in clean water and neutralize.
- Grit blast and repeat acid and rinse/neutralize cycles until visible evidence of coating is gone. Maximum total soak time in acid bath is 90 minutes.

Recommended Heat Tint Cycle:

- Grit blast component with 220 grit aluminum oxide at 60 max. psi.
- 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.

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 a 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 6. 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.

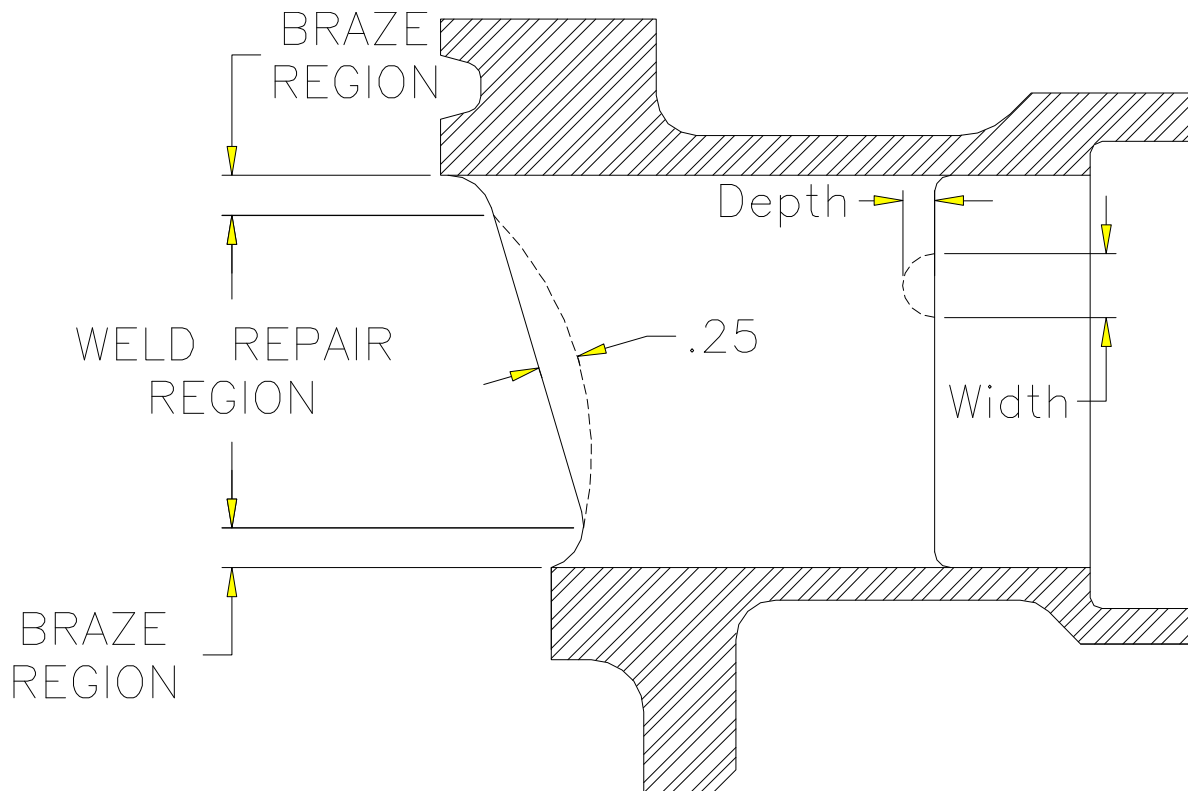


FIGURE 6

T-066 Inspection Limits and Repair

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 is Inconel 625, 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 MAR-M-247. 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.

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 #3. (ASTM E 1417 is an acceptable alternative). No linear indications are allowed. Note that indications less than .015" are considered uninterpretable 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; otherwise, they must be considered one large indication.

EFA of repaired nozzles must be checked and modified if not within acceptable range. See Sections 6 or 10. Repaired airfoils must meet minimum dimensions shown in Figure 5.

4.0 Weld Repair of Inner / Outer Bands: Welding can be used to repair cracks that are too wide for furnace braze. (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 5.

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.

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 Furnace Braze Repair of Vane Ring: Furnace brazing 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 that the braze 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.

T-066 Inspection Limits and Repair

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.

6.0 Optional EFA Measurement (diaphragm assembly not installed): Extex recommends measuring airflow prior to coating in addition to the final airflow measurement, see Section 10. Note that coating typically reduces EFA by approx.03. Parts which flow within the pre-coating EFA limits below can be forwarded to the next operation, coating. Parts which do not meet the pre-coating EFA limits must be adjusted at this operation. Final adjustment during the final EFA operation shall be held under .01 to help prevent coating cracks. Pre-coating EFA can be adjusted by performing one of the approved methods in Section 10.

Part Number	Post-Coating Effective Flow Area
E23062753	3.295 - 3.305
E23062754	3.185 - 3.199

7.0 Coating: Gas path surfaces of the vane ring **must** be recoated with an aluminide or platinum-aluminide coating. *All applicable part numbers may be coated with either an aluminide or platinum-aluminide coating regardless of the prior coating.* Acceptable coating processes include standard "in the pack" diffusion-based aluminides, "over the pack" vapor phase aluminides and the more sophisticated platinum-aluminides.

8.0 Heat Treatment: As part of the repair, the vane ring must be solution heat treated to 2200°F for 2 hours and then precipitation hardened (strengthened) at 1600°F for 20 hours. All or part of this cycle may occur during the coating cycle.

9.0 Installation of Diaphragm Subassembly: Install a new or serviceable diaphragm subassembly and lock it into place by GTA welding the locking keys to the ring of the diaphragm assembly. If the surface to be welded on has been aluminide coated, then remove coating via localized blending. Blending to a depth of .005 will be sufficient to remove the coating. Orientation of the diaphragm to the vane ring is presented in Figure 3.

NOTE: Inconel 625 (IN 625) or Hast X filler rod should be used when welding keys to the diaphragm assembly. Heat input should be minimized to prevent warping of the vane ring.

10.0 Final EFA Measurement (diaphragm assembly installed): Repaired nozzle assemblies must be airflow tested after repair. Acceptable EFA limits are presented below.

Part Number	Post-Coating Effective Flow Area
E23062753	3.295 - 3.305
E23062754	3.295 - 3.305

Parts which do not meet the EFA limits can be adjusted by performing one of the following approved methods.

Shot Peen Adjustment (open or close EFA)

T-066 Inspection Limits and Repair

- For post-coating adjustment, shot peen intensity should be kept at a minimum to prevent coating damage.
- 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.
- A protective maskant over the trailing edges can help reduce the likelihood of coating cracks without diminishing the effectiveness of the shot peen media.

NOTE: Glass bead peening may also be used for post-coating EFA adjustment. This process reduces the tendency to crack the coating.

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 .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: After airfoil restoration cycle, mark "EFA" and new Effective Flow Area. If the part was coated with Pt-Al, a -P suffix must be added to the P/N. If the part was coated with a simple aluminide, the -P suffix is not required and must be obliterated if present.