GRAND GULF NUCLEAR STATION

UNIT 1

PHASE 1B PROGRAM

DIVISION I D/G DISASSEMBLY, REINSPECTION,

AND

VERIFICATION OF DIVISION II D/G

AS-MANUFACTURED SIMILARITY

July, 1984

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

TABLES

APPENDICES

ABSTRACT

This report contains a description of the NRC ordered reinspection program undertaken by MP&L for the Division I TDI diesel engine. The report includes a description of inspections performed, the inspection results, the nature of nonconforming components, their disposition, and conclusions on the integrity of the Division I diesel engine. Also contained in this report is a comparison of the as-manufactured similarity between the Division I and the Division II TDI diesels. Based on information provided in this report, MP&L concludes that a complete disassembly and reinspection of the Unit 1, Division II diesel engine is not warranted. It is MP&L's position that inspection activities on the Division II diesel engine should be limited to that diesel's turbochargers, as discussed herein.

This report provides the technical justification for concluding, with a high level of confidence, that the GGNS TDI diesel engines will operate reliably and perform their design safety function through at least the first refueling outage.

MP&L will also take appropriate action, as necessary, in response to significant new findings from the TDI Owners Group which may affect the GGNS TDI diesel generators. Together these programs should adequately demonstrate the GGNS TDI diesel generator reliability for the life of the plant.

1.0 INTRODUCTION

Grand Gulf Nuclear Station (GGNS), Unit 1 is equipped with three standby diesel generators, two of which were manufactured by Transamerica Delavel, Inc. (TDI). These two diesel generators (D/G) are sources of A.C. emergency power to the GGNS Division I and Division II ESF buses. The third D/G set, dedicated to the High Pressure Core Spray system, was manufactured by the Electro-motive Division (EMD) of General Motors.

Mississippi Power and Light (MP&L) received an NRC Order in a letter from E. G. Adensam to J. P. McGaughy dated May 22, 1984, which required MP&L to disassemble and reinspect the Division I TDI diesel engine. The Safety Evaluation Report accompanying the order also required a validation of the as-manufactured similarity of the two TDI diesel engines based on a review of the manufacturer's QA records.

This report contains a detailed description of the reinspection of the Division I TDI diesel engine performed during May and June, 1984. The results of this inspection demonstrate the integrity of this engine. Section 4.0 presents the results of a comparison of the as-manufactured similarity between the Division I and Division II TDI diesel engines. This section also includes discussion on the similarities between the two engines regarding maintenance, inspection, and operating histories, as well as the implications of the recent inspection of the Division I engine.

2.0 SUMMARY

Mississippi Power and Light Company (MP&L) has conducted a disassembly and reinspection of the Division I TDI diesel engine which is a source of standby emergency power for the Grand Gulf Nuclear Station, Unit 1 (GGNS-1). The reinspection was performed in accordance with the MP&L TDI diesel revalidation program and instructions contained in the Nuclear Regulatory Commission (NRC) Order of May 22, 1984. Concurrently, manufacturer's records were reviewed to verify that the Division II diesel engine key components have as-manufactured similarity to the Division I engine key components.

The one area of concern discovered during the inspection was the failure of three turbocharger stationary nozzle ring retaining capscrews due to intergranular stress corrosion cracking. These failures had no impact on the operation of the diesel up to the time of the inspection. No significant conditions were found during the inspection which could preclude the diesel engine from performing its intended design safety function. Components with minor anomalies were documented and dispositioned to be reworked or accepted as is.

The capscrews were replaced by the turbocharger manufacturer with passivated capscrews of the same material. Investigative and corrective actions will be performed on the Division II diesel engine turbocharger stationary nozzle ring capscrews, upon the return of Division I diesel generator to operable status.

A review of the Division I and II D/G material, design, and process records provided sufficient objective evidence that the two engines have similar as-manufactured quality for key engine components.

MP&L has reassembled the Division I engine and has proceeded to perform the operability tests before returning the engine to service.

3.0 DIVISION I D/G INSPECTION SCOPE AND RESULTS

The GGNS inspection plan was developed from the results of recent inspections on other disassembled TDI diesel engines, and information relating to the operating history for these engines. Recommendations from the TDI D/G Owner's Group, Southwest Research Institute (SWRI), and other independent consultants as well as specific additional inspections contained in the NRC order were factored into the plan. The inspections performed met or exceeded all requirements imposed by the NRC order.

3.1 SCOPE OF INSPECTIONS

The scope of the current reinspection program is listed in Table 3-1. This table specifies the characteristics verified and the inspection/test methods employed (i.e., visual, dimensional, non-destructive examinations (NDE), hardness tests, torque checks, and material comparator tests).

The inspections and tests were performed or witnessed by qualified level 2 or 3 inspectors using approved procedures and acceptance criteria. Details of the acceptance criteria can be found in Appendix 1 to this report.

3.2 RESULTS OF INSPECTIONS

A summary of the results of the inspections performed is provided in Table 3-1. Each component inspected is addressed below in further detail.

3.2.1 CYLINDER HEADS

1. Valve Seats (Intake and Exhaust)

Visual inspection revealed conditions normal to wear. There was no evidence of hot gas leakage (blow-by) or unusual degradation of the seating surfaces. Minor pits were

detected, but evidence of hot gas erosion through the pitted areas was not identified.

Liquid Penetrant Examinations revealed discontinuities inherent to the welding of hard facing alloys. There was no indication of seat degradation associated with the discontinuities discovered. Five of the sixteen heads examined exhibited rounded indications with the physical size of the discontinuities being less than 1/16". The discontinuities are attributed to gas formation (porosity) during the welding process. Two of the five heads revealed a singular crack approximately 1/2" in length across the seat (both exhaust). Based on a metallurgical evaluation completed in June, 1984, the singular cracks pose no problem with the operability of the head.

Other minor linear indications were identified, these were attributed to the as cast condition of the material being examined. The other 11 heads revealed no discontinuities.

2. Fire Deck

The firing deck surface of each head was measured for thickness using ultrasonics. The thinnest area located was 0.404 inches and the thickest 0.791 inches. There were many variations in thickness due to the as-cast condition of the head and structures located in the head internals. A complete examination grid was used to assure that measurements would be representative.

Magnetic Particle (Fluorescent) Examination of the fire deck identified numerous linear indications. None of the indications gave the appearance of cracking. Further evaluation of these indications using a stereo microscope determined that the indications were a result of mechanical scratches and/or tool marks. There were no relevant indications identified on the 16 heads.

3. Fuel Nozzle Cavity

The wall of the cavity was measured for thickness with ultrasonic instruments. The results varied with the thinnest area being 0.403 inches and the thickest being 0.8116 inches. Measurements were taken at 1/3 depth and 2/3 depth from the spring side of the head. This data was recorded for information only.

4. Intake and Exhaust Valves

The valves were examined visually with emphasis on the following areas:

- Seat area of valve head

  Overall condition of seating area was acceptable. Minor pitting was detected but no evidence of blow-by was identified. The pits did not affect the seating ability of the valve. The valve seating surface exhibited uniform metallic rings which indicate adequate seating. No indications of scuffing or erosion were identified.

- Valve Stem Surface

  Visual inspection of the stem area revealed no evidence of scuffing or scoring. Wear patterns on the stem indicated a uniform travel in the guide. Two conditions related to the chrome plating were identified on a number of the valves. These conditions were evaluated by a metallurgist and the following conclusions were drawn.

a. Four stems exhibited minor flaking of the hard chromium plating from the stem material. Through the use of a stereo microscope, it was determined that the flaking was due to a lack of bond between the plating and the underlying carbon steel. This appears to be localized to a third of the valve stem near the valve head. The flaking of the plating is not expected to affect the performance of the valve. The exposed area of the valve stem did not exhibit pitting or corrosion. The flaking of the plating occurs in small fragments, essentially in powder form, and not in large pieces. Therefore, the flakes in themselves will not affect valve performance or cause damage to associated engine parts.

b. Localized craze cracking on the hard chrome plated areas was found on thirteen valves when examined with a stereo microscope. A transparent greenish corrosion layer usually associated with pitting and intergranular corrosion was also found in these areas. These discontinuities may eventually result in flaking of the plating in the affected area. It is very unlikely that the craze cracking or pitting will in any way affect valve performance.

Flaking of the chrome is not considered detrimental to the operation of the valve. The chrome serves as a wear surface for valve travel through the valve guide. As long as there is sufficient chrome remaining to act as a guide the entire surface need not be plated.

- Retaining Area

  A visual examination of the retaining area of the valve stems did not reveal any evidence of distress. All retaining areas were acceptable. Only machining marks from the manufacturing process were noted.

- Rocker Arm Contact Surface

  A visual examination of this area revealed evidence of minor wear on the outer edge of the valve stem circumference. This appears to be the match line of the lifter from the rocker arm. The wear noted was not abnormal or indicative of a potential material failure, but normal for parts performing this function.

- Valve Blend Radius

  A liquid penetrant examination of the valve blend radius on the intake and exhaust valves identified two valves each with a rounded indication. The bleed-out size of the two indications were 1/32" and 3/64". There was no evidence of material distress associated with these discontinuities.

- Valve Guides

  The visual examination performed showed evidence of normal guide wear with minor pitting. No condition was identified which affected the operation of the valve. Reassembly of the heads required stroking the valve through the guide. There was no unusual amount of drag identified in the stroking process.

5. Springs

All valve springs were visually inspected and no apparent defects were noted. No valve springs with the gray and brown stripe color code that was the subject of 10CFR21 report by TDI were found.

Conclusion

The cylinder heads and associated components have been thoroughly evaluated as to overall material quality as well as service induced conditions and MP&L has dispositioned these components as acceptable.

3.2.2 ENGINE BASE ASSEMBLY

Main Bearing Cap to Engine Base Saddle Mating Surface

A visual and liquid penetrant examination was performed on the main bearing to engine base saddle mating surfaces of main journal numbers four, six, and eight. These examinations did not identify any relevant indications.

Conclusion

The inspection results verify that the engine base bearing saddles will adequately perform their intended function.

3.2.3 ROCKER ARM CAPSCREWS

Rocker Arm Capscrews

The rocker arm capscrews were visually and magnetic particle examined and no relevant indications were identified.

Rocker Arm Drive Studs

The rocker arm drive studs were visually examined. No cracks, looseness, or incomplete engagement was found.

Conclusions

The results of the examinations verify that the rocker arm capscrews will continue to perform their intended function.

3.2.4 CYLINDER BLOCK

Internal Block Casting Surface

The visual inspection of the internal block casting surface found some surface indications attributed to the casting and manufacturing process. There were no signs of material distress and no relevant indications were found.

Cylinder Block Liner Seat

The visual inspection found corrosion indications on the upper portion of the ring for the number eight cylinder on the left bank. Small nicks were also noted on the bottom edge of the ring. The corrosion indications were in the water jacket area and are normal for this area. No sign of leakage was found. The nicks resulted from maintenance activities and were not service induced. All cylinder block liner seats were acceptable.

Cylinder Block to Head Mating Surface and Liner Landing Area

The liquid penetrant examinations disclosed no rejectable indications on the cylinder block to head mating surfaces and liner landing area. The dimensional checks found that all dimensions were within the acceptance criteria.

Conclusions

No condition was found which would have prevented the cylinder block from adequately performing its intended function. The results indicate that the Division I cylinder blocks are sound.

3.2.5 CYLINDER HEAD STUDS

Studs

The visual inspection noted many instances of flat crests on the top threads of the studs and one instance of minor thread damage to the bottom threads. On the left bank cylinder head number 3, stud numbers 4 and 5, a 360° discernible surface indication was found on the stud shanks.

All of the thread indications have been attributed to maintenance activities and were not service induced. The surface indications on studs 4 and 5 on head 3 appeared to have been formed during the manufacturing process. The conditions noted would not have led to stud failure.

Stud numbers 4 and 5 in the left bank number 3 cylinder head were replaced with new studs as a maintenance item. The damaged threads on the other studs were chased with a die and re-examined. All of the studs were acceptable.

Conclusions

No condition was found which would have prevented the studs from continuing to perform their function. The results of the inspection demonstrate that the cylinder head studs are adequate for their intended function.

3.2.6 CYLINDER LINER

Internal Cylinder Liner Surface

Visual inspections of the internal cylinder liner were performed after honing. All cylinder liners were accepted.

On the right bank number 8 cylinder liner, a liquid penetrant examination was performed at the request of an NRC staff consultant after surface anomalies were noted. This examination verified that the liner surface contained no discernible indications and the liner was accepted.

Outside Surface of Cylinder Walls

Visual inspections identified surface indications on the outside surface of left bank cylinder liner numbers 1 and 4. These indications were mechanical in nature and caused by tooling and handling. Liquid penetrant examinations of these areas confirmed that no cracks were present and the liners were acceptable. No relevant indications were found on the other cylinder liners.

Cylinder Liner Dimensions

The dimensional checks of the cylinder liners found that the tolerances were all within the acceptance criteria except for cylinder liner numbers 1 and 8 from the right bank. These

cylinder liners did not meet the recommended clearance for cylinder liner-to-cylinder block bore measurements by only 0.002". There were no signs of any distress due to smaller clearances as evidenced by the NDE. Cylinder liner numbers right bank 1 and 8 were subsequently sanded to comply with the recommended tolerance and reused.

Conclusions

The visual inspections and confirming liquid penetrant examinations of suspect areas revealed no conditions which would have prevented the cylinder liners from continuing to perform their intended function.

3.2.7 TURBOCHARGER

Turbocharger Bracket-Bolting

The turbocharger bracket bolting was visually inspected and a material comparator test was performed. There were no relevant indications found and the material comparator results were acceptable. Torque checks were also performed and no relaxation was found. Based on the results, the turbocharger bracket-bolts will continue to perform their function.

Turbocharger Welds

A visual inspection of the turbocharger mounting welds and system piping welds was performed. The inspection results for the welds identified no evidence of leakage or cracks. Based on the inspection results the welds are acceptable for their intended service.

Turbocharger Thrust Bearings

The turbocharger thrust bearings were visually examined and determined to be acceptable. Rotor float measurements indicated that the bearings on both turbochargers were in like-new condition with clearances of 0.0075" and 0.0085" when measured wet (with oil film). The thrust bearings would have continued to perform their intended function, but were replaced by the manufacturer in accordance with standard practice during refurbishment of turbochargers.

Turbocharger Stationary Nozzle Ring

Upon disassembly of the right bank turbocharger, two broken capscrews on the stationary nozzle ring were identified. One broken capscrew on the left bank turbocharger stationary nozzle ring was also identified. The heads of the broken capscrews on the right bank were not found and were assumed to have passed through the turbine into the silencer. The capscrew head on the left bank was still secured by the lockwire and was recovered.

A metallurgical examination of the broken capscrews was performed. It was determined that the failure mechanism was intergranular stress corrosion cracking. The corrosive media is thought to be sulphuric and sulphurous acid vapors in the exhaust gases.

After examination by liquid penetrant testing, new stationary nozzle rings were installed on both turbochargers. New capscrews of the same material, which were passivated to provide increased corrosion resistance, were installed in the nozzle rings. An engineering study is underway to determine the need for a different capscrew material.

Stationary Nozzle Ring

There is a great deal of experience with these turbochargers with very few reported instances of failed capscrews. Other nuclear plants have substantial experience with no reported problems with these capscrews after an average of 300 to 400 hours. Because of this experience and the recently completed inspection of the GGNS Division II turbochargers, which had no broken capscrews after approximately 900 hours of operation, MP&L feels confident that the capscrews are satisfactory until at least the first refueling outage.

Conclusions

The results of the inspections on all aspects of the turbochargers are sufficient to qualify them through at least the first cycle of plant operation.

3.2.8 CONNECTING ROD BOXES

Rack Teeth Surfaces

Visual inspections disclosed minor fretting on the rack teeth of all connecting rod boxes. Correspondence with the vendor confirmed that this fretting was normal and comparable to other connecting rods with similar number of operating hours. The rack teeth were lightly polished with a soft stone and visually re-examined. The rack teeth were blued, per the NRC staff's request, and evaluated by the vendor representative as being acceptable. This inspection was witnessed by MP&L.

Connecting Rod Box External Machined Surface

Magnetic particle (wet fluorescent) and liquid penetrant examinations of the connecting rod box machined surfaces did not identify any indications.

Female Threads in Connecting Rod Box

The visual inspection (magnified borescopic) disclosed pitting in one hole of box number 1, galling in one hole of box number 6, and heavy galling in one hole of box number 5. No other rejectable surface indications were found. All identified conditions were caused by maintenance activities and were not service induced. The master rod and connecting rod box on crank throw number five which showed heavy galling were replaced. The threaded holes in all other boxes were cleaned with a tap and reinspected. The reinspection results were acceptable for all connecting rod box assemblies. A calculation of stress on the galled bolts showed that connecting rod box assembly number 5 would not have failed.

Connecting Rod Box Bolt Hole Radii

Liquid penetrant examinations were performed on the top and bottom radii adjacent to the threads. No relevant indications were identified.

Connecting Rod Box Bolts

The visual inspection disclosed that approximately 50% of the connecting rod bolts had minor galling. This galling was caused during disassembly and reassembly activities and was not service induced. No relaxation of the torque was found during the disassembly torque check. All bolts were replaced per NRC staff recommendation. The replacement bolts were visually inspected, magnetic particle examined and found acceptable. Special care was taken to ensure that both the bolt and the connecting rod thread surfaces were thoroughly lubricated with a finely dispersed mixture of powdered graphite and oil to prevent future galling.

The results of the magnetic particle (wet fluorescent) examinations were accepted. Both the original bolts and replacement bolts were examined with no relevant indications identified.

Connecting Rod Box Dimensions

The connecting rod box assemblies were dimensionally inspected in accordance with the vendor manual. All inspection results showed that the assemblies were within the recommended tolerances.

Conclusions

The Division I inspections found no condition which would have prevented the connecting rod boxes and bolts from continuing to perform their function. The conditions found were not service induced and had no impact on the parts performance. A calculation of stress on the galled bolts showed that there was a factor of safety of 2.8 for tension and 3.0 for shear for a preload of 2600 ft-lb. Based on the above, the Division I connecting rod boxes and bolts are adequate for their intended service.

3.2.9 PISTON PIN BUSHINGS

Sides and Internal Bore of Piston Pin Bushing

Liquid penetrant examinations were performed on all piston pin bushings. The examination disclosed various minor surface indications that were acceptable and which were attributed to normal surface wear. A small piece of debris was found and removed from the oil groove of the number 1 left bank piston pin bushing. Dimensional checks verified the bushings to be within the manufacturer's tolerances.

Conclusions

The results of the liquid penetrant examination and the dimensional checks demonstrate that the piston pin bushings are adequate to perform their intended service.

3.2.10 CONNECTING ROD BEARING SHELLS

Connecting Rod Bearing Shells

All bearing shells were liquid penetrant examined (both sides) with no significant findings. Indications were reported and accepted.

The shells (except #7) were x-rayed to the criteria approved by the Owner's Group and all accepted. The better quality bearing halves were assigned to be reinstalled as upper bearings. Bearing No. 7 was provided to Failure Analysis Associates (FaAA) for metallurgical evaluation in an effort to gain more knowledge in bearing castings.

The bearing shells exhibited minimum wear with minor scratching induced from debris normal to engine reassemblies. The existence of hour glass wear patterns was not discernible in the bearings. Bearing No. 4 had an approximately 1/2" wide wipe on one end due to a minor build-up of metal on the crankshaft that had not been sufficiently removed during the piston skirt change out of January 1984. The crankshaft was polished lightly to remove the metallic residue. Bearing number 4 was determined to be satisfactory for further service, but was replaced as a maintenance item.

Conclusion

No evidence of bearing degradation was identified other than minor babbit flaking. Number 4 and 7 bearings were replaced with new ones meeting all acceptance criteria. All other bearings met the criteria for use and were reinstalled.

3.2.11 PISTONS

Piston Skirts

A magnetic particle examination was made on the machined bolt flat area and adjoining radius on the inside of all piston skirts. Numerous small linear indications 1/16" long or less were noted. These indications were within the established acceptance criteria and were determined not to be service induced.

These indications were compared to the original baseline data obtained from examinations of the piston skirts prior to installation in January of 1984. All the piston skirts were acceptable with no relevant indications.

Piston Crowns

A magnetic particle examination was performed on the complete firing surface and the stud bore area of all piston crowns. Indications were found on the number 3 left bank and number 5 left bank piston crowns. The indication on the number 3 left bank crown firing surface was examined under a stereo microscope and found to be a surface scratch. The indications on the number 5 left bank piston crown firing surface and on the stud bore area were also examined under a stereo microscope and determined to be surface indications induced during handling and machining. Further examination of the indications was made by liquid penetrant examinations

of the number 3 left bank and the number 5 left bank piston crowns. The liquid penetrant examination verified that the piston crowns had no relevant indications and were acceptable. Dimensional checks of the piston skirts and piston skirt to crown clearances were within tolerances.

Piston Studs

Magnetic particle and visual examinations were made on all piston crown studs. The visual examination revealed that all studs had a very small number of nicks due to handling and that all studs were acceptable. The magnetic particle examination disclosed some indications that were within the established acceptance criteria. All studs were acceptable with no relevant indications. Dimensional checks and torque checks on the piston studs were within tolerances.

Piston Pins

A visual examination of the piston pins disclosed one pin with a small piece of chrome flaked off. The area was not part of the wear surface and all pins were acceptable for further service. Dimensional checks of the piston pins were within tolerances.

Conclusions

The recent inspection of the MP&L Unit 1 Division I TDI engine AE skirts following 270 hours of operation (including over 160 hours of rated power operation) disclosed no relevant indications in the AE piston skirts, crowns or studs. Other AE skirts have accumulated over 6000 hours in a stationary generating plant, 600 hours in an advanced development engine and over 300 hours in a Shoreham engine. Inspection of these skirts also disclosed no relevant indications.

3.2.12 CRANKSHAFT

Crankshaft Journal Oil Holes

Liquid penetrant, visual and dimensional examinations were performed on the number 4, 6, and 8 main crankshaft journal oil holes as recommended by the TDI D/G Owners Group.

The examination disclosed no apparent defects and an oil hole radius of approximately 7/16". A visual inspection on the crankshaft crankpins disclosed minor scratches on rod journals 1, 2, 3, 6, 7 and 8. Also, the number 4 journal showed indications of a slight metal deposit as described in Section 3.2.10. The journals were cleaned and the number 4 journal was lightly polished.

Conclusion

Scratching of the journals was attributed to small debris that enters the engine when the engine is disassembled and open to the outside environment. This occurs even though extreme care is taken to maintain a high level of cleanliness. These scratches are considered inconsequential and will not affect engine performance.

Independent dynamic analysis of the GGNS crankshaft, NDE of the Division I and II crankshafts during December, 1983, and January 1984, and the additional recent inspections demonstrate that the crankshafts in the GGNS Unit 1 TDI engines are adequate for their intended service.

3.2.13 CRANKCASE COVERS: GASKET AND BOLTING

Gaskets

Visual inspection of the crankcase cover gaskets was performed. The gaskets showed no signs of leakage indicating that adequate seating was being achieved. However, as a maintenance item all crankcase cover gaskets were replaced.

Bolting

Visual inspection of the crankcase cover bolts disclosed that all bolts were acceptable for further service. Upon reassembly of the crankcase covers, the torque check results of the bolting were acceptable.

Conclusions

The crankcase covers gasket and bolting were found to be adequate for their intended service.

3.2.14 PUSH RODS

Friction Weld Area of Push Rods

Liquid penetrant and visual examinations were performed on all connector, exhaust, and intake push rods. These examinations disclosed only two 1/8" machine marks and no relevant indications.

Conclusions

Prior to this engine disassembly a push rod was removed from the Division I engine after 100 hours of engine operation. It was metallurgically examined and no discernible indications were found.

Another push rod was fatigue tested to 10^7 cycles and examined. Again, no apparent defects or relevant indications were found.

The disassembly inspection results, in addition to the testing and examination of the two push rods discussed above, demonstrate that the friction welded push rods are adequate for their intended service.

3.2.15 AIR START VALVE CAPSCREWS

Capscrew Length

Dimensional checks of the air start valve capscrews length disclosed that eight of the capscrews did not conform with the acceptance criteria for length. Further dimensional checks of the tapped holes in the cylinder heads for these eight capscrews verified that the capscrews had not bottomed out and did not affect the operation of the engine.

The out of tolerance capscrews were machined to bring the length within tolerance and returned to service.

Conclusion

The inspection showed that sufficient clearance exists to prevent the capscrews from bottoming in the tapped holes; therefore, the out of tolerance condition is not an item of concern.

3.2.16 FUEL OIL INJECTION TUBING

Visual Inspection

During Maintenance Post-Inspection Testing, the fuel oil injection tubing was subject to visual inspection for leakage and proper fit up between the fuel pump and injection nozzle. No evidence of leakage was identified.

Conclusion

The fuel oil injection tubing is determined to be acceptable for its intended service.

3.2.17 CYLINDER HEAD SUBCOVER

Subcovers

Visual inspection of subcover assemblies for surface casting discontinuities was performed.

Eleven of the sixteen subcover assemblies were found to be free of visual surface indications. The remaining five subcover assemblies were found to contain crack indications.

Four of the cracks were considered to be surface cracks. The cracks were located in radial areas at material thickness transitions away from the high stressed regions of the mechanical connections. Therefore, the cracks are attributed to shrinkage induced by the casting process. There was no evidence of crack propagation. This indicates that these are benign cracks and were not detrimental to engine operability.

There was evidence that the fifth crack was initiated by maintenance activities and is considered an isolated case. The crack was located in a thin section of the cover well removed from the threaded area that was not part of the main load carrying portion. The predominant load in the region was a compressive force, hence propagation was not likely. This crack also was not detrimental to engine operability.

Conclusions

These indications would not have had an effect on engine operability and the five subcover assemblies were dispositioned accept-as-is. However, as a maintenance item, the five subcovers were replaced.

3.2.18 IDLER GEARS

Visual Inspection

Slight pitting was noted on all teeth of the left hand idler gear and recorded on high resolution video tapes. The pitting was in the region below the main contact band where the idler gear contacts the camshaft gear. Also noted was a small knife edge on the leading face of the gear teeth of the left hand idler gear. A visual examination of this area revealed no indications of cracking or other unusual wear. The idler gears and the camshaft gears are both forged 4340 quenched and tempered steel, normalized at 1475°F for 3 hours, furnace cooled for 6 hours at 1200°F, machined and subsequently heat treated to 1550°F for 3 hours, quenched in agitated oil, and drawn at 875°F for 4 hours. The measured hardness was approximately 360 BHN. The gears were acceptable.

Conclusion

Based on the visual inspection and the hardness test, the idler gears are considered sound and are adequate for their intended function.

3.3 PRELOAD RELAXATION CHECK

Torque Checks

Cylinder head studs, rocker arm capscrews, air start valve capscrews, piston crown attachment studs, connecting rod bolts, link pin bolts, turbocharger bracket bolting, and subcover capscrews were all verified for adequate preload torque values during the disassembly of the engine. None of the bolts, capscrews or studs exhibited any signs of preload relaxation with the exception of the air start valve capscrews. The air start valve capscrews showed slight preload relaxation which is expected due to the presence of copper gaskets between the air start valves and cylinder head.

Conclusions

These torque value verifications demonstrated that preload is adequate and maintained on the various bolts, capscrews and studs that were checked and that the bolts, capscrews and studs are adequate for their intended service.

3.4 MATERIALS EVALUATION - DIVISION I TDI DIESEL ENGINE

An evaluation of the materials used in the fabrication of key components has been conducted in accordance with the requirements of the Design Review and Quality Revalidation Program (DR/QR program) for the TDI Diesel Generators. This evaluation was conducted to verify the physical characteristics of component materials to predetermined requirements set forth in the DR/QR program. The results are as follows:

3.4.1 Component: Rocker Arm Capscrews

Part Number: 02-390-01-0G

Material: Carbon Steel - Heat Treated

Properties: Tensile Strength (Approx.) - 166 ksi
Hardness Average - BHN 330

Remarks: Commercial Grade Carbon Steel capscrews Heat Treated to meet TDI Material Specification GB-011-150. Adequate for the application.

3.4.2 Component: Air Start Valve Capscrews

Part Number: GB-032-114

Material: SAE Grade 5 Capscrews

Properties:

Sample No.	Hardness (BHN)
RB-4	368
RB-8	356
LB-2	342
LB-8	361

Tensile Strength (Approx.) - 179 ksi

Remarks: The Air Start Valve Capscrews are Commercial Grade 5, purchased to TDI Material Specification GB-032-114 and meet the requirements of ASTM A449.

3.4.3 Component: Cylinder Head Studs

Part Number: 03-315-01-0A

Material: AISI A4140 Quenched and Tempered Steel

Properties:

Sample No.	Hardness (BHN)
LB#1, Bolt 1	274
LB#5, Bolt 1	254
RB#8, Bolt 8	262
LB#1, Bolt 1	261
RB#3, Bolt 4	242
RB#1, Bolt 5	256
RB#6, Bolt 8	276
LB#8, Bolt 1	256

Tensile Strength (Approx.) - 130 ksi

Remarks: Cylinder Head Studs purchased as standard commercial parts. Purchased to requirements of TDI Drawing 03-315-01-0A. The evaluation indicates that the samples tested meet the properties of quenched and tempered AISI A4140 steel.

3.4.4 Component: Idler Gear, Right Bank

Part Number: N.A.

Material: AISI 4340 Quenched and Tempered Steel

Properties:

Sample No.		Hardness (BHN)
RB Idler Gear	0°	363
	90°	359
	180°	358
	170°	361

Tensile Strength (Approx.) - 180 ksi

Remarks: The Idler Gear meets the requirements for forged 4340 quenched and tempered steel. Based on the above information and its typical properties (tensile 185 ksi, yield 150 ksi, impact 75 ft-lbs) the material is adequate for the application.

3.4.5 Component: Connecting Rod Box Bolts

Part Number: 02-340-04-AB (Lower Bolts)
02-340-05-AA (Upper Bolts)

Material: AISI A4140, Hot Rolled and Normalized

Properties:

Sample No.	Hardness (BHN)
Rod 4 Bolt 5	290
Rod 2 Bolt 1	313
Rod 6 Bolt 6	290
Rod 1 Bolt 5	327
Rod 8 Bolt 4	280
Rod 1 Bolt 4	289

Tensile Strength (Approx.) 141 thru 153 ksi

Remarks: The Connecting Rod Box Bolts were purchased to requirements of TDI Drawing Numbers 02-340-04-AB and 02-340-05-AA. The bolts meet the requirements of Commercial Grade AISI A4140, Hot Rolled and Normalized Steel.

3.4.6 Component: Connecting Rod Box

Part Number: 02-340-05-AE

Material: Alloy Steel - Heat Treated

Properties: Tensile Strength Minimum - 110 ksi
Hardness Average - BHN 243

Remarks; Commercial Grade Alloy Steel Normalized, quenched, and tempered. Adequate for this application.

3.5 MATERIAL VERIFICATION (COMPARISON)

The engine material verification included a comparison between known material specimens and actual materials used in the Grand Gulf engine components. The comparison was made by the thermoelectric method with a Technicorp WT Alloy Separator Model 850/950 Mod P1. Within the useful sensitivity range of this test instrument, the materials were verified for the following components.

Rocker Arm Capscrews
Cylinder Studs
Cylinder Liner
Connecting Rod Bushing (Piston Pin Bushing)
Turbocharger Bracket Bolts
Connecting Rod Box

TABLE 3-1
RESULTS OF DIVISION I D/G INSPECTION

Part Name	Part Number	Task Descriptions	Inspection Type						Notes
			Visual	Dmsn	NDE	Hdns	Torque	Comp.	
Cylinder Heads	03-360-03-0F	Inspect Valve Seating Surfaces and Fire Deck	ACC		UT-ACC LP-ACC MT-ACC				
Engine Base Assembly	02-305-05-AA	LP Main Bearing Saddle Area and Visually Inspect Mating Surfaces	ACC		LP-ACC		ACC		
Rocker Arm Capscrews	02-390-01-0B	Verify Torque MT Capscrews and Verify Material	ACC		MT-ACC	ACC	ACC	ACC	
Cylinder Block	02-315-03-AE	Visual NDE Map for Baseline	ACC	ACC	LP-ACC				
Cylinder Head Studs	03-315-01-0A	Visually Inspect Head Studs, Material Hardness and Torque Verification on Studs	*			ACC	ACC	ACC	* See Section 3
Cylinder Liners	02-315-02-0G	Visually Inspect Dimensional Material Verification	ACC	*	**	ACC		ACC	* See Section 3 ** See Note 1 at end of Table
Landing Area			ACC	*	LP-ACC				* See Section 3
Turbocharger Welds		Visual	ACC						

TABLE 3-1
RESULTS OF DIVISION I D/G INSPECTION

Part Name	Part Number	Task Descriptions	Inspection Type						Notes
			Visual	Dmsn	NDE	Hdns	Torque	Comp.	
Bracket-Bolting	GB-001-143 GB-001-117	Verify Torque Material	ACC				ACC	ACC	
Turbocharger Thrust Bearings	MP-022-000	Visual	ACC	ACC					
Connecting Rod Boxes	02-340-05-AG	Rod Box (out-of-engine)	*	ACC	LP-ACC MT-ACC	ACC		ACC	* See Section 3
	02-340-04-AB	Rod Box Bolts (out-of-engine)	*		MT-ACC		ACC		* See Section 3
Connecting Rod Bushings (Wrist Pin)	R-3195	NDE and Material Verification		ACC	LP-ACC			ACC	
Connecting Rod Bearing Shells	02-340-04-AG	RT Shells, Visual Inspection, and Dimensional Check	ACC	ACC	RT-ACC LP-ACC				
Piston Skirts Crowns Studs	03-341-04-AE 03-340-04-AE 03-341-04-AB	MT Skirts Crowns and Studs	ACC	ACC	MT-ACC	ACC	ACC	ACC	
Crankshaft	1A-5445	Torsiograph Deflection Test		***					*** See Note 2 at end of Table
Crankcase Covers: Gaskets and Bolting		Visual Inspection Verify Torque	ACC				ACC		
Fuel Oil Injection Tube	1A-2600	Visual Inspection for Leaks	ACC						

TABLE 3-1
RESULTS OF DIVISION I D/G INSPECTION

Part Name	Part Number	Task Descriptions	Inspection Type						Notes
			Visual	Dmsn	NDE	Hdns	Torque	Comp.	
Intake/Exhaust Push Rods	02-390-06-AB	Visual	ACC		LP-ACC				
Connector Push Rods	02-390-07-AG	Visual	ACC		LP-ACC				
Air Start Valve Capscrews	GB-032-114	Visual	ACC	*			ACC		* See Section 3
Subcovers		Visual	*						* See Section 3
Idler Gear			*						* See Section 3

1. LP of all cylinder liners was not performed per exemption granted by NRC letter, dated June 20, 1984.

2. Deflection test was acceptable. Torsiograph is to be performed.

3. Principal Abbreviations
   Dmsn - Dimensional Check
   Hdns - Hardness Check
   Comp. - Material Verification (Comparison)
   ACC - Acceptable

4.0 COMPARISON OF DIVISION I D/G TO DIVISION II D/G

4.1 INTRODUCTION

In the Safety Evaluation Report supporting the NRC Order dated May 22, 1984 which required MP&L to disassemble, inspect and test the Division I TDI diesel engine, the NRC staff stated the following position regarding the Division II TDI diesel engine:

> " ... action to be taken on the Division 2 engine would be contingent upon the results of the inspections conducted on the Division 1 engine and MP&L's ability to demonstrate, through a review of the manufacturer's QA records, that the two engines have similar 'as-manufactured' quality."

In reaching its conclusion that the Division II TDI diesel engine is satisfactory for continued service in its current condition and that it need not be subjected to a detailed reinspection prior to restart following the first refueling outage, MP&L performed a review and assessment which included the following considerations:

- The similarity of the design and as-manufactured quality of the two TDI diesel engines.
- The similarity of the post manufacture upgrades which have been accomplished for each of the two TDI diesel engines.
- A comparison of the operating history and operational performance of the two TDI diesel engines.
- The similarity of the results of the previous inspections of each of the two diesel engines which were performed in December 1983 - January 1984.
- The results of the recently completed inspection of the Division I TDI diesel engine and the implications of these results with respect to the condition of the Division II TDI diesel engine.

The results of these reviews and assessments are presented below. Where indicated, additional information is presented in Appendices to this report.

4.2 SIMILARITY OF MATERIALS, DESIGN, AND FABRICATION OF KEY COMPONENTS FOR AS-MANUFACTURED QUALITY

MP&L - Nuclear Plant Engineering, Bechtel Engineering, and Bechtel Supplier Quality Personnel have conducted an in-depth investigation of the records related to materials, design, and manufacture of the GGNS TDI diesel engines at the TDI manufacturing facility in Oakland, California. This investigation has verified that the key engine components of both engines are of similar as-manufactured quality (i.e., designed, fabricated, inspected, tested, and installed).

The investigation for each key component was performed and the following conclusions were made:

- The Division I and II engines were manufactured in 1975-1977. As discussed in Section 4.3, some of the key components were replaced by MP&L after the receipt of the engines. For the parts that were replaced by MP&L, the records review included the manufacturing time frame with respect to the specific component.

- A review of the TDI material specifications, including any revisions issued, for each component was conducted. This review resulted in the determination that the key components are of the same type material for both engines. In addition, based on TDI fabrication records and MP&L's previous (12/83-1/84) disassembly records, heat numbers (where available), were obtained prior to the investigation for most components. The heat numbers were then traced to a Certified Material Test Report (CMTR), and the CMTR was reviewed for physical and chemical property conformance to the applicable TDI material specification or industry standard.

With respect to items purchased for TDI inventory such as bolts, capscrews, tubing, etc., the material used for GGNS could not be pinpointed in all cases. For these type items, typical supplier's certifications were reviewed for conformance to the TDI purchase specification and were found to be in conformance with the requirements imposed.

This review resulted in the determination that sufficient objective evidence exists to conclude that the materials used and installed in the Division I and II engines are of similar as-manufactured quality.

- A review of the purchasing and fabrication (forging, final machining, and assembly) drawings was conducted. The purpose of this review was to determine if any of the key component characteristics or quality standards had been changed as a result of the time frame of manufacture. This review resulted in the determination that the drawings used for the purchasing/fabrication provided key components in the Division I and II engines with similar as-manufactured quality.

- A review of the manufacturing processes performed by TDI on the key engine components was conducted. The purpose of this review was to determine if any process performed on the key components had been revised as a result of the different time frame of manufacture for the engines. This review resulted in the determination that the key components of the Division I and II engine were subjected to the same processes by TDI, and that the key components were processed with similar as-manufactured quality.

As previously noted, some components were purchased by TDI for stock items, such as, bolts, capscrews, tubing, etc., and the only process that could be verified for these type of items was TDI's receipt inspection and installation processes. For these items, the typical receipt inspection plans and installation and

inspection route sheets employed by TDI were found to be adequate for determining similar as-manufactured quality.

A detailed report which provides a review and conclusion for each component is provided in Appendix 2.

4.3 TDI DIESEL ENGINE UPGRADES

Subsequent to manufacture and delivery of the engines to GGNS, several component upgrades have been implemented on the GGNS Unit 1 TDI diesel engines. These upgrades (enhancements) were initiated as a result of TDI Service Information Memos, 10CFR21 reports, and operating experience. MP&L performed the upgrade on both GGNS Unit 1 TDI engines. Two (2) key component upgrades were:

1) The installation of improved lower stressed "AE" style piston skirts based on early evaluations of a potential problem with the modified "AF" style piston skirt at Shoreham; and

2) Installation of the new friction welded connector, intake, and exhaust push rods after encountering cracked welds in the ball and tube type push rod.

The implementation of these upgrades on both engines provides evidence that both engines have maintained their similar reliability and as-built quality of key components.

4.4 DIVISION I AND II D/G OPERATING HISTORY

Division I and Division II engines have demonstrated a highly successful start history. A summary of operating history of the Division I and II diesel engines is provided in Table 4-1. As can be seen the number of starts on the Division I diesel engine is substantially greater than the Division II Diesel, by a factor of approximately 3. The Division I diesel engine run time also exceeds the Division II diesel engine by approximately 500 hours, and Division I full load hours exceed the Division II diesel engine by approximately 30 hours.

The inspection results for the Division I diesel engine, which has the higher number of operated hours and starts, demonstrated that the physical condition of the engine is acceptable and is adequate to perform its intended design function. Therefore, the physical condition of the Division II engine with approximately 66% less starts and approximately 36% less run time is also considered to be acceptable and is adequate to perform its intended design function. Therefore, an additional complete disassembly and inspection of the Division II diesel engine is not warranted. The only inspection activity on this engine proposed is discussed in Section 4.7.

Table 4-1 shows the combined starting reliability data of the two GGNS Unit I TDI diesel engines for the period June 16, 1982 through April 4, 1984. The valid test start reliability is 98.6%. The start reliability demonstrates that the GGNS Division I and II diesels are highly reliable and will perform as designed.

In efforts to enhance reliability of the GGNS Unit I engines, several component replacements (upgrades) were made. A comparison of the various components and inservice hours is provided in Table 4-2. Table 4-3 provides approximate engine hours for Division I and II under various loads.

4.5 PREVIOUS INSPECTIONS

The Division I and II diesel engines were inspected in December 1983 - January, 1984.[1] The purpose of this disassembly of the engines was to inspect the modified "AF" pistons which led to the installation of the improved "AE" style piston skirts. During this disassembly, additional component verifications were performed on both Unit I TDI diesel engines. Non-destructive examinations were performed on the

---

1. Details on the results of this inspection are provided in the MP&L letter AECM-84/0103, submitted to the NRC on February 20, 1984.

new and old piston skirts, crankshaft, and original and replacement cylinder heads. In addition, non-destructive examination of several Division II connecting rod bearings was performed. Visual examinations and dimensional checks were also performed for piston pin bushings, cylinder liners, crankshafts, connecting rod bearings, piston tie studs, piston crowns and skirts, piston pins, and one main bearing per engine. Visual examinations and dimensional checks were also completed for replacement connecting rod bearings and replacement piston rings. The connecting rod bearings and piston rings were replaced as part of normal maintenance practice. One cylinder liner was also replaced due to damage incurred during engine disassembly. Due to very conservative acceptance criteria two cylinder heads on the Division II diesel engine and six cylinder heads on the Division I diesel engine were also replaced. Subsequent to the inspection, a metallurgical evaluation was performed on one of the rejected cylinder heads. As a result of the evaluation, new acceptance criteria were developed and used during the recent inspection.

The results of the previously conducted inspections of the Division I and II diesels demonstrated the similarity of the engines. The results of both the December 1983 - January 1984 and the recent ordered inspection were comparable for dimensional checks and visual examinations. The as-manufactured quality and similarity of the key engine components is determined to be acceptable based on the results of a comparison between the January 1984 and recent inspections.

4.6 APPLICABILITY OF DIVISION I INSPECTION TO DIVISION II

The disassembly and inspections performed on the Division I diesel engine key components provide objective evidence that the Division II diesel engine key components are sound and will perform their function in the engine. Those items that were determined to be acceptable in the Division I engine should also be acceptable in the Division II engine. Those items in which some indications were found, were determined to have no impact on the operation of the diesel.

Therefore, based on the inspection results and as-manufactured quality comparison, the Division II diesel engine is physically equivalent to the Division I engine.

The only exception is the retaining capscrews on the stationary nozzle ring of the turbochargers. These will be replaced on the Division II turbochargers.

Due to the approximately 66% fewer starts and 36% less run time the Division II key components have experienced lower cumulative stresses. Therefore, those key components subject to service induced conditions will be in a better quality state in the Division II engine than was found in the Division I engine. All evidence points to the conclusion that the Division II diesel engine key components will continue to function properly until at least the first refueling outage.

4.7 CONCLUSIONS

The NRC ordered reinspection of the GGNS Unit 1, Division I TDI diesel engine has been completed. The overall results of the inspection verify that the TDI engines at GGNS, Unit 1 are highly reliable and are adequate to perform their intended design function. The inspection results also provide additional confirmation of satisfactory engine key component reliability.

The stringent reinspection included liquid penetrant, magnetic particle, ultrasonic, radiographic, hardness, dimensional, material comparator and visual examinations of key components. Some service induced indications (e.g., chrome flaking on valve stems) and manufacturing indications (e.g., machine marks) were found. Engineering evaluations determined that these conditions were inconsequential with respect to component reliability. Some components, although determined to be adequate for continued service, were replaced with new parts as part of good maintenance practice. No defects or indications were found that would affect engine operation.

One area of concern was identified -- the failure of the stationary nozzle ring retaining capscrews in the turbochargers due to intergranular stress corrosion cracking. These failures had no effect on the operation of the Division I D/G. The capscrews were replaced with more corrosion resistant passivated capscrews of the same material. Investigative and corrective actions will be performed on the Division II diesel engine turbochargers' stationary nozzle ring capscrews.

A review of the Division I and II D/G material, design, and process records provids sufficient objective evidence as to the quality of the engines and confirms that the two engines have similar as-manufactured quality for the key engine components. In addition, the two Unit 1 TDI diesel engines compare favorably in regard to maintenance and operating history, as well as in inspections conducted prior to the recent disassembly of the Division I diesel engine. Based on these favorable comparisons, MP&L concludes that a complete disassembly and inspection of the Unit 1, Division II diesel engine is not warranted at this time. Inspection activities on the Division II engine should be limited to that engine's turbochargers based on an evaluation of the recent inspection of the Division I engine.

TABLE 4 - 1

GGNS D/G OPERATING DATA

Total Run Hours	Division I	Division II
Shop and Pre-Op Run Time (Hrs)	535	252
Since Date of OL Run Time (Hrs)	862	641
Total Run Time (Hrs) (3)	1397	893
TOTAL NO. OF STARTS (3)		
Delaval Shop Runs (1)	310 (2)	5
Pre-Operational Runs	60	60
Since Date of OL Runs	192	125
Total Starts	552	190

Notes:
1. Source of Information - Delaval Technical Manuals.
2. Division I engine had 300 prototype runs for reliability testing.
3. Data as of June 11, 1984.

Table 4 - 1 (Cont'd)

DIESEL RELIABILITY

Valid Tests:	Div I -	84
	Div II -	53
		137
Valid Failures:	2 (1 Div I - Control System Electrical Component) (1-Div I - Unknown)	
Start Reliability:	98.5%	

Valid tests and failures are as defined in Regulatory Guides 1.108.

Data as of April 4, 1984

TABLE 4 - 2

APPROXIMATE IN-SERVICE HOURS
of
D/G COMPONENTS

	DIVISION I*	DIVISION II**
AE Piston Skirts	270	200
Connecting Rod Bearings	270	200
Main Bearings	1400	900
Crankshafts	1400	900
Blocks	1400	900
Base	1400	900
Camshafts	1400	900
Push Rods	270	150
Main Conn. Rods	1400	900
Link Rods	1 @ 800	900
	7 @ 1400	
Piston Pin Bushings	1 @ 800	900
	15 @ 1400	
Liners	3 @ 800	1 @ 200
	13 @ 1400	15 @ 900
Cylinder Heads	6 @ 270	2 @ 200
	10 @ 1400	14 @ 900
Piston Crowns	1400	900
Turbochargers	560	900

Note: *Data as of disassembly, May 25, 1984
**Data as of July 1, 1984

TABLE 4 - 3

DIVISION I AND II APPROXIMATE
RUN HOURS UNDER LOAD SINCE ORGINALLY FURNISHED
PISTON SKIRTS WERE MODIFIED IN NOVERMBER, 1981 TO APRIL 4, 1984

Load, + 5%	Division I Hours	Division II Hours
less than 50	14	12
50 - 60	450	316
60 - 99	75	13
100	301	251
110	14	10

5.0 POST INSPECTION TESTING

5.1 POST MAINTENANCE TESTING

Following reassembly of the Division I diesel engine the engine was carefully inspected for loose parts or debris. The engine was then started and run at no-load for approximately 15 minutes while engine checks and adjustments were made. The engine was stopped, crankcase side cover was removed, and engine internals were checked for indications of excessive heat. The inspection was completed satisfactorily and the engine started and run at 20% for approximately one hour. The engine was stopped and the above inspections repeated. The engine was then run at levels varying between 25% to 100% load for approximately 8 hours. At the completion of the break-in run hot crankshaft deflection checks and cold compression readings were taken. All inspections and checks were satisfactory. The break-in run recommended by the vendor in accordance with TDI SIM 99 was completed without any engine malfunctions or engine incidents.[1]

5.2 NRC REQUIRED TESTING

In addition to the vendor's recommended testing following reassembly of the Division I TDI diesel engine, the NRC order of May 22, 1984 required additional testing consisting of ten modified starts to 40% load, two fast starts to 70% load and one 24-hour run at 70% load. MP&L's letter of July 2, 1984 (AECM-84/0325) to the NRC provided the NRC with MP&L's clarifications/interpretations of the required testing. In accordance with AECM-84/0325, the following testing was completed for the Division I TDI diesel engine.

---

[1] An incident unrelated to the Division I TDI diesel engine involving the failure of a linear reactor coil for the generator phase shift circuit occurred during the engine break-in run. All three coils were replaced and the break-in run was completed. An investigation and evaluation of the incident is in progress.

- 10 modified starts with 3-5 minute loadings to 50% load and runs for a minimum of one hour at 50% load were performed.

- 2 fast starts were performed as follows:

  a. The Division I D/G was returned to standby status, manually started from the control room and then synchronized to its associated ESF bus.

  b. The ESF bus was disconnected from offsite power.

  c. The LPCS pump, RHR A pump, and SSW A pump were manually started. (Manual pump start evolution for all three pumps was accomplished in approximately 10 seconds).

  d. The ESF bus was synchronized back to offsite power and the Division I D/G was loaded to at least 70% load (4900 KW).

  e. The LPCS and RHR pumps were shutdown, as considered necessary, and the load maintained at the minimum of 70% for 4 hours, as required by the Order.

- One 24-hour run at a minimum of 70% load was performed.

The thirteen tests described above were performed successively without failure, malfunction or abnormal conditions occurring. No abnormal engine parameters were observed. The GGNS Unit 1, Division I TDI diesel engine, throughout the break-in run and NRC required testing, has demonstrated that the GGNS TDI diesel engines are reliable engines and provides a high level of confidence that the engines will adequately perform their design function.

6.0 GGNS PROPOSED AUGMENTED MAINTENANCE/SURVEILLANCE PROGRAM

GGNS 1 has an established detailed maintenance and surveillance program in place for the Division I and II TDI diesel generators (Table 6-1). The May - June 1984 inspection results for the Division I diesel engine contained in Section 3.0 of this report confirm that this program has been highly effective and is adequate to assure the integrity and reliability of the GGNS Unit 1 TDI diesel engines.

Prior to this investigation, the NRC proposed an augmented maintenance/ surveillance program for the TDI diesel engines to detect degradation or deterioration of the diesel engines.

MP&L's submittal of May 6, 1984 to the NRC (AECM-84/0271) proposed to conduct a confirmatory inspection of a TDI D/G at the first refueling outage, and in the interim period prior to the inspection, to conduct an augmented surveillance and preventative maintenance program to ensure that degradation or deterioration of the engines did not occur prior to the inspection.

However, this proposal was not accepted by the NRC. As specified in the NRC Order of May 22, 1984, the TDI diesel engine with the longest running time was reinspected during May - June of 1984 to verify the integrity of the engine and engine key components. At the time of the inspection, the Division I D/G had approximately 1397 hours of run time of which approximately 315 hours were at 100% load or greater. Several key components, piston skirts and connecting rod bearings, were replaced during the January 1984, disassembly and thus have less operating hours than the overall engine. The Division I engine, since the January 1984 disassembly, has over 270 hours run time, of which approximately 160 were at 100% rated load or greater, and 51 starts. The 100% load hours after January 1984 were accumulated during extended test runs that demonstrated the reliability of the GGNS TDI engines.

Based on the May - June 1984 Division I TDI diesel engine inspection and on the Division I TDI diesel engine operating hours and starts accumulated since the last inspection (January - 1984), a revised augmented maintenance/surveillance program for the GGNS Unit 1 TDI diesel engines is being proposed. This program will remain in effect until such time that the reliability of the TDI engines has been demonstrated as adequate by MP&L and the TDI D/G Owner's Group to the satisfaction of the NRC.

The MP&L revised augmented program is shown in Table 6-2 and is discussed below. It should be noted that MP&L's proposed program differs somewhat from that which was proposed by the NRC staff in its letter to MP&L, dated April 25, 1984. These differences, which are discussed below, are primarily related to the frequency of the surveillances rather than to their content. MP&L has concluded that its proposed program, when considered in the context of the results of the recent inspection of the Division I diesel generator and of the Division I and Division II diesel generator operating history and performance, fully meets the intent and purpose of the program proposed by the NRC staff and its consultants. The changes in the surveillance frequencies provide the additional benefit of minimizing unnecessary and undesirable downtime of the diesel generators. On balance, MP&L has concluded that its proposed program will provided a higher degree of assurance that the GGNS Unit I TDI diesel generators will be available to perform their intended emergency safety functions.

6.1 NRC Proposed Addition- Cylinder Heads

Following engine shutdown, the engine should be rolled over with air pressure after four hours (during cooldown) with the indicator cocks open. Subsequent to cooldown, the engine should be air rolled every 24 hours. Any cylinder heads discovered leaking must be replaced. MP&L should confirm that the written procedures are adequate to ensure that the cocks are closed following each air roll.

Discussion

Air rolling of diesels with the cylinder head cocks open is utilized to check for oil, fuel or water that could leak into the cylinders when the diesel is in standby. The NRC has proposed air rolling four hours after shutdown and every 24 hours thereafter. It should be noted that during an air roll the diesel must be placed in the maintenance mode and thus will be inoperable for approximately one hour out of twenty-four. As a consequence, the NRC proposed requirements for air rolling would add approximately four percent to the unavailability of each diesel.

The recent inspection results after 270 hours of operation also show that the heads are adequate for their intended service and extended operation. All indications were dispositioned as acceptable and the heads reinstalled for further service.

MP&L Proposed Action

To reduce the amount of unavailability and still check for water that could indicate a head leak the engines will be air rolled four hours after engine shutdown, and once weekly thereafter. The engines are also routinely air rolled prior to a planned start. Any cylinder head discovered leaking will be replaced. Air rolling of the diesel engines is addressed in the system operating instruction.

These commitments, when considered in the context of the results of the recent inspection, fully meet the intent and purpose of the NRC staff's position on the matter.

6.2 NRC Proposed Addition - Engine Block and Base

Inspect the engine block and base every month or 24 hours of operation, whichever comes first. The inspection should be an external visual inspection requiring no disassembly. No other special maintenance is required if any defects found are "non-critical." Non-critical indications are defined as not causing oil or water leakage, not propagating; and not adversely affecting cylinder liners or stud holes.

Discussion

A monthly visual inspection of the engine block and base for oil and water will aid in the early detection of a potential engine malfunction.

MP&L Proposed Action

An external visual inspection of the engine block and base will be performed after every 24 hours of engine operation or monthly, whichever comes first, for water and oil leakage.

6.3 NRC Proposed Addition - Connecting Rods

After each interval of 24 starts, 50 hours of operation or 6 months, whichever comes first, all connecting rods should be visually inspected and all connecting rod bolts should be retorqued and the results recorded.

Discussion

This proposed action is estimated to cause the diesel to be inoperable for approximately four days or an additional 2% unavailability of each diesel. In accordance with GGNS Technical Specifications, this will also require starting the other two diesels within two hours to

demonstrate their operability and then once every 8 hours thereafter until the first diesel is returned to an operable status. In addition, if the diesel is not returned to an operable status within 72 hours the technical specifications require a plant shutdown.

The recent Division I diesel engine inspections found no degradation or deterioration of the connecting rods since the last inspection in January of 1984. Over 270 hours of operation and 51 starts had been accumulated on the Division I engines since the previous inspection. A torque check of the connecting rod bolts after this accumulation of run time and starts showed that no preload relaxation had occurred and is not expected to occur.

MP&L Proposed Action

It is proposed that all connecting rods be visually inspected, the preload of the connecting rod bolts be checked and the results recorded. These actions will be performed after every 50 starts or after every 270 hours of engine operation or at the first refueling outage, whichever comes first.

These commitments, when considered in the context of the results of the recent inspection, fully meet the intent and purpose of the NRC staff's position on this matter.

6.4 NRC Proposed Addition - Lube Oil Checks

The lube oil should be checked for water following preoperational testing and then weekly and after each 24 hours of operation, whichever comes first. It should also be checked on a monthly basis for particulates and chemical contaminants associated with wear of bushings and bearings. Also at intervals of one month, a sample should be collected from the bottom of the sump to check for water. All filters and strainers should also be checked monthly.

Discussion

The Division I and II diesel generator lube oil is sampled on a quarterly basis and analyzed by Mobil. The analysis includes viscosity, fuel dilution, reserve alkalinity, insolubles, water, glycol, oxidation, nitration, silicon (dirt), iron, aluminum, copper, lead, tin, chromium and boron. Based on the anlysis an Action Code is assigned by Mobil to the sample indicating action to take and areas to investigate to determine the reason for unsatisfactory sample results. These action codes are listed in Table 6-3. To date samples have not indicated any abnormal wear of D/G engine parts.

The results of the recent inspection also show that degradation, deterioration, and abnormal wear has not occurred since the previous inspection.

MP&L Proposed Action

The lube oil in the TDI diesel engines has been sampled on a quarterly basis since 1981 and to date has not indicated any signs of abnormal wear of D/G engine parts. The recent inspection also showed no signs of abnormal wear, however, MP&L proposes to sample the lube oil on a monthly basis. On a monthly basis the lube oil will be sampled as described in the discussion above, a sample from the bottom of the sump will be inspected for water and filter differential pressures will be recorded. Sampling the sump requires removal of an inspection plate causing the diesel to be declared inoperable for an hour. In addition, the lube oil will be sampled following the NRC required testing.

These commitments, when considered in the context of the results of the recent inspection, fully meet the intent and purpose of the NRC staff's position on this matter.

6.5 NRC Proposed Action - Cylinder Head Studs, Rocker Arm Capscrews, Air Start Valve Capscrews

Each month 25% of the capscrews should be spot checked for torque.

Discussion

Checking the cylinder head studs requires a significant amount of disassembly of the engine. To inspect the head studs, the removal of the top cover, subcover and rocker assemblies, and connector push rods is required. Reassembly is in reverse, however now, valve adjustments are required. Valve adjustment is also required if air start valve capscrew torques are checked due to the connector push rod being removed to gain access to the capscrews. Any one of these checks will cause the diesel to be inoperable for some period of time. Again the Technical Specifications requirement to start the other diesels within two hours to verify operability and once per eight hours thereafter and to shutdown the plant if the diesel generator is out of service for greater than 72 hours will apply. The NRC proposed action adds over 7% to the unavailability of each diesel.

In addition, the recent inspection of the Division I diesel engine showed that preload relaxation with the exception of the air start valve capscrews had not occurred with over 270 hours of operation and 51 starts since torquing at the previous engine inspection. The slight preload relaxation on the air start valves is considered normal as discussed in Section 3.0 of this report.

MP&L Proposed Action

It is proposed that 25 percent of the head studs, rocker arm capscrews, and the air start valve capscrews will be checked for preload relaxation after 270 hours of engine operation or the first refueling outage, whichever occurs first.

These commitments, when considered in the context of the results of the recent inspection, fully meet the intent and purpose of the NRC staff's position on this matter.

6.6 NRC Proposed Action - Push Rods

Following preoperational testing and then subsequently after each 24 hours of operation, cams, tappets, push rods, etc., should be visually checked. This can be done one at a time with the engine shutdown but without affecting its availability for service.

Discussion

The checking of cams and tappets requires the removal of side covers. Push rods require the removal of the subcover inspection covers. This causes the engine to be tagged out and declared inoperable for approximately a day adding 1% to the unavailability of the engine.

All intake, exhaust, and connector push rods on both Unit 1 engines are the new friction welded push rods. FaAA has performed a cyclic fatigue test to 10^7 cycles on a sample friction welded push rod after which it was examined metallurgically. No signs of cracking or deterioration of the welded joint was observed. In addition, MP&L removed a push rod from an engine following 100 hours of operation after the January 1984 disassembly. This push rod showed no signs of abnormal wear and when subjected to a metallurgical examination showed no cracking. The recent inspection also showed that the push rods are in excellent condition after several hundred hours of operation.

MP&L Proposed Action

Cams, tappets and push rods will be visually checked after 270 hours of engine operation or during the first refueling outage, whichever comes first.

These commitments, when considered in the context of the results of the recent inspection, fully meet the intent and purpose of the NRC staff's position on this matter.

6.7 NRC Proposed Action - Additional Surveillance

During standby, the lube oil filter pressure drop should be checked daily rather than monthly as suggested by MP&L. Hot and cold deflection tests of the crankshaft should be performed every 6 months with the hot deflection test performed within 15 minutes of engine shutdown.

During engine operation, the exhaust temperature for each cylinder should be monitored continuously by the operator and recorded on a log at hourly intervals, as should the temperatures entering and existing the turbocharger. Other temperature and pressure readings for which the engine is instrumented should also be monitored continuously, and recorded hourly, or more frequently if specified by the manufacturer. These should at least include lube oil, jacket water, intercooler temperature, and air pressure. If the engine is equipped with an accelerometer on the main bearings and turbocharger, these should also be monitored continuously and recorded at hourly intervals. If the engine is not equipped with an accelerometer at these points, main bearing oil temperature should be monitored continuously and recorded hourly. Also, lube oil filter pressure should be monitored daily during engine operation.

Discussion

During surveillance testing the following parameters are monitored and recorded after the engine has stabilized at operating temperatures and pressures.

Lube oil pressure
Turbo L.O. R.F. pressure
Turbo L.O. L.F. pressure
Fuel oil pressure
Fuel oil filter D/P
Combustion air L.B. pressure
Combustion air R.B. pressure
Lube oil filter D/P
Jacket water pressure
Crankcase vacuum
Cylinder temperature
Stack temperatures
Lube oil inlet temperatures
Lube oil outlet temperatures
Jacket water inlet temperatures
Jacket water outlet temperatures
Tachometer
Hourmeter

If the above parameters are outside of the expected tolerance an evaluation of engine condition is made.

Vibration switches located on the turbocharger and on the diesel do not provide direct indication, however, they trip the diesel if abnormal vibration occurs. In addition to these switches during each monthly surveillance test vibration data is acquired at eleven selected points with portable vibration meters. Four points are on the turbochargers, six are on the diesel engine and one on the generator bearing. Limits have been established for the points on the diesel engines.

It is unlikely that hot crankshaft deflection checks could be performed within 15 minutes of engine shutdown. Removal of inspection covers and setup of instruments will take longer than 15 minutes. Previous hot and cold deflection checks have been within manufacturer's tolerances and show that the crankshaft is adequate for continued service.

MP&L Proposed Action

Check the prelube oil filter pressure drop on a daily basis. Continue to record engine parameters during surveillance testing. Perform hot and cold crankshaft deflection checks after 270 hours of operation and as expeditiously as possible following engine shutdown.

These commitments, when considered in the context of the results of the recent inspection, fully meet the intent and purpose of the NRC staff's position on this matter.

6.8 Consequences of Proposed Actions

The above inspections must be performed on a staggered basis to prevent both diesels from being inoperable at the same time. This results in at least one of the diesels being unavailable approximately 30% of the time for the NRC proposed inspections and less than 9% of the time for the MP&L proposal.

Therefore, the MP&L proposal provides a greater safety margin due to the substantially increased availability compared to the NRC proposed program.

TABLE 6-1

GGNS D/G MAINTENANCE TESTING PROGRAM

Maintenance Action	Frequency (NOTE 1)	Procedure
Observe and record lubricating oil and jacket water temperatures.	Every 8 hr	02-S-01-5
Drain all low point water collectors, "Y" strainers and air receiver tanks in starting air system.	D (once/24 hr)	02-S-01-5
Check engine and auxiliary equipment for oil, water, and fuel oil leaks.	D (once/24 hr)	02-S-01-5
Check level of lubricating oil in sump tank, governor, and pedestal bearing.	D (once/24 hr)	02-S-01-5
Check fuel pump racks for freedom of movement through full limit of travel.	D	02-S-01-5 Monthly Lube
Check air butterfly valve(s) and actuating cylinders for freedom of operation.	W	02-S-01-5
Turn on electrical fuel oil booster pump for a short time and circulate fuel through system. Check strainers for clean fuel.	W	02-S-01-5
Clean and inspect "Y" strainers in starting air system. NOTE: If fouling of strainers is such that more frequent inspection is indicated, shorten inspection interval.	6 months	07-S-24-P75-D015-1
Check lubricating oil filter pressure differential.	M	06-OP-P75-M-0001/2
Inspect and clean air filter in starting air distributor. If conditions warrant, inspect more frequently.	M	Vendor Manual

NOTE 1: D - Daily; W - Weekly; M - Monthly; Q - Quarterly; A/S - Annual/Each Shutdown; and BA/AS - Bi-Annual/Alternate Shutdowns.

(CONTINUED)

Maintenance Action	Frequency	Procedure
Drain water and/or sludge from lubricating oil full flow filter.	M	Flushed/3 Months 07-1-24-P75-D-010-1
If differential pressure indicates, check strainer screens in fuel oil and lubricating oil pressure strainer.	M	06-OP-P75-M-0001/2
Check lubricating oil for fuel dilution with a viscosimeter.	M (Previously, every 3 months)	08-S-04-363
Send lubricating oil sample to laboratory for analysis.	Q	07-S-01-22
Drain lubricating oil system. Clean sump and strainers, refill with new oil.	A/S(2)	07-S-24-P75-E001AB-14
Check pH factor of jacket water.	M	PH 08-S-04-107/109 NITRITE 08-S-04-342

NOTE 2: This item performed only if deemed necessary as a result of lube oil analysis.

(CONTINUED)

Maintenance Action	Frequency	Procedure
Remove alternate left side doors and examine inside of engine for any abnormal conditions.	A/S	07-1-24-P75-E001-1
Check hydraulic valve lifters for operation and proper adjustment.	A/S	07-S-24-P75-E001AB-2
Remove fuel injector nozzles, clean, reset, and reinstall.	A/S	07-S-24-P75-E001AB-11
Check connecting rods and link rod bearing clearances.	A/S (3)	
Check and record crankshaft deflections.	A/S	07-S-24-P75-E001AB-9
Visually inspect foundation for breaks in bond between sole plates and grout.	A/S (4)	
Check foundation bolts for correct torque. Retorque as necessary then recheck crankshaft deflections.	A/S	07-S-24-P75-E001AB-13
Check lubricating oil jets at gears for plugged or broken lines.	A/S	07-S-24-P75-E001AB-12
Remove cam covers and cylinder head covers. Inspect cams, tappets, rollers, rocker arms, push rods, springs, and valve guides.	A/S	07-S-24-P75-EC01AB-3

NOTE 3: Bearing wear is determined by analysis of metal concentration in lube oil analysis.

NOTE 4: This inspection is performed during foundation bolt torque check and crankshaft deflection check.

(CONTINUED)

Maintenance Action	Frequency	Procedure
Drain governor oil, clean, flush, refill with new oil. If necessary, replace governor drive coupling.	A/S	07-S-24-P75-E001AB-5 07-S-24-P75-E001AB-4
Remove turbocharger(s). Disassemble and clean.	5 Years	07-S-24-P75-E001AB-7
Check cold compression pressures and maximum firing pressures. If indicated, remove cylinder heads, grind valves. Check valves and liners.	A/S	07-S-24-P75-E001AB-15 07-S-24-P75-E001AB-16
Inspect gears for general condition. Check backlash and replace worn gears exceeding maximum clearance.	BA/AS	07-S-24-P75-E001AB-18
Remove fuel injection pumps. Disassemble, clean, repair, and adjust as necessary.	BA/AS	07-S-24-P75-B004-11
Remove end plates from heat exchangers and intercoolers. Examine and clean as necessary.	BA/AS	07-S-24-P75-B004-1
Check main bearings.	BA/AS	07-S-24-P75-E001AB-8
Inspect intake air filter oil distribution plate. Change oil in filter.	A/S (5)	07-S-24-P75-B004-1

NOTE 5: Oil in the air filter is sampled and changed only when deemed necessary by oil analysis results.

TABLE 6-2

MP&L PROPOSED ADDITIONAL MAINTENANCE & INSPECTION

Maintenance Action	Frequency
Air Roll Engine	At 4 hours after shutdown and weekly thereafter. Engine also air rolled prior to manual start.
Visually inspect externals of engine block and base	Monthly or after every 24 hours of engine operation, whichever comes first.
Visually inspect all connecting rods and check for preload relaxation	After 50 starts or 270 hours of engine operation, whichever comes first.
Inspect lubricating oil for water	Monthly or after 24 hours of engine operation, whichever comes first.
Send lubricating oil sample to laboratory for analysis	Monthly
Inspect sample of lubricating oil from bottom of sump for water	Monthly
Record filter differential pressures	Monthly
Check 25% of cylinder head studs, rocker arm capscrews, air start valve capscrews for preload relaxation	After 270 hours of engine operation or refueling outage whichever comes first.
Visually check cams tappets and push rods	After 270 hours of engine operation or refueling outage, whichever comes first.
Check crankshaft deflection	After 270 hours of engine operation or refueling outage, whichever comes first.
Record pertinent engine operating parameters	During surveillance testing.
Clean and inspect "Y" strainers in starting air system	Quarterly

TABLE 6-3

LUBE OIL ANALYSIS ACTION CODES

Action Code	Problem	Investigate
0	No Action Required	All findings normal (no asterisk) or moderately out of line (Asterisk only).
1	High Oil Viscosity	Use of a higher viscosity oil; excessive insolubles or oxidized oil. (See Action Codes 4 and/or 7).
2	Fuel Dilution or Low Oil Viscosity	Defective injectors; worn injection pump; leaking transfer pump seals or fuel lines; use of a lower viscosity oil.
3	Low Reserve Alkalinity	Over-extended oil service; dilution with another oil; poor combustion; high sulfur fuel.
4	Excessive Insolubles (Fuel Soot)	Poor combustion; ineffective oil filters; low compressure pressure; restricted air intake; faulty blower, injection timing, injectors or injection pump delivery valves.
5	Excessive Water	Low engine temperature for any reason; outside contamination; cooling system leaks (See Action Code 6).
6	Cooling System Leaks	(Glycol, Chromium, and/or Boron) leaking gasket; loose head; cracked head or liner; leaking sleeve seals; leaking oil cooler.
7	Excessive Oil Oxidation	Over-Extended oil service; low oil level; high engine temperatures; clogged oil cooler; faulty shutters or thermostat, piston ring blow-by.
8	Excessive Oil Nitration	Over-extended oil service; poor ignition and/or combustion; low oil temperatures high air intake temperatures.

TABLE 6-3
(CONTINUED)

Action Code	Problem	Investigate
9a	Excessive Silicon with High Abrasive Wear	Faulty air cleaner; leaks in air induction system; outside contamination.
9b	High Silicon with Low or Moderate Wear	Oil contact with silicon rubber or sealing compound; use of a silicone defoamant; improper sampling and/or oil handling procedures.
10	High Wear Metals	(Iron, Aluminum, Copper, Lead, Tin and/or Chromium; Silver for EMD engines only). Worn or failed bearing, cylinder liner, piston, bushing, etc.; contaminated containers; improper sampling.
11	High Zinc Level (EMD Engines Only)	Contamination with a zinc-containing product.
12	Oil/Operating Condition Unsatisfactory	Submit another sample to determine effectiveness of corrective action taken.
13	Oil/Operating Condition Unsatisfactory	Drain oil if dilution persists above 5%.
14	Oil/Operating Condition Unsatisfactory	Drain oil immediately and change filter.

7.0 CONCLUSIONS

In accordance with the NRC Order of May 22, 1984, MP&L has disassembled the GGNS Unit 1, Division I TDI diesel engine and has completed detailed examinations of key engine components using stringent acceptance criteria. No defects or indications were found that would affect engine operation. The overall results of the examinations verified that the TDI engines at GGNS, Unit 1 are highly reliable and are adequate to perform their intended design function. These examination results, in conjunction with the Division I/Division II Similarity Assessment described in Section 4 of this Report, provides sufficient objective evidence as to the quality of the engines and demonstrates that additional inspections of the Division II D/G, with the exception of the turbocharger, are not warranted. Due to the discovery of failed capscrews on the stationary nozzle ring of the Division I D/G turbochargers, the Division II D/G turbochargers will be examined.

In summary, based on the knowledge obtained from the similarity of materials, design, and as-manufactured quality; the similarity of the results of the previous inspections performed in December 1983 - January 1984; the similarity of the post-manufacture upgrades and replacements of components; the operating history and operational performance; and the results of the recently completed inspection of Division I engine, it is concluded that the Division I and II GGNS diesel engines, in their present state, are satisfactory for continued service.

APPENDIX 1

GRAND GULF NUCLEAR STATION

UNIT 1

TDI DIESEL ENGINE KEY COMPONENT INSPECTION PLAN

REVISION 2

June 22, 1984

INDEX

ABSTRACT

As a result of recent meetings between the NRC and MP&L concerning the TDI Diesel Generator reliability and in support of full power operation of Grand Gulf Unit 1, an inspection plan of key engine components has been assembled for verifying and ensuring that adequate reliability of the engines exists.

The attached Key Engine Component Inspection Plan contains the acceptance criteria for use during the Division I diesel engine disassembly and inspection verification program.

The acceptance criteria contained herein are, to the maximum extent practical, based on industrial acceptance standards for the base materials. Where none are established, attempts have been made to provide acceptance criteria through agreement between MP&L, TDI and the Owner's Group. Those areas lacking product information have been left open for further consideration at a later date.

NOTES

1. Drawings are provided for information only.

2. Changes to the procedures or criteria specified herein may be made through the use of the M-183.1, Appendix R.

3. Plant Quality witness is required on all required inspections and examinations.

4. Photographs should be taken wherever possible to aid in future evaluation of indications identified through examinations.

5. When acceptance criteria is based on material thickness, the thickness shall be determined in the most unfavorable orientation in the examination area.

6. Material comparitor reading will be recorded and reported to NPE.

7. Material hardness reading will be recorded and reported to NPE.

8. Indications believed to be non-relevent shall be evaluated in accordance with the procedure applicable to the method which detected them and/or by visual exam using enlargement equipment (i.e., microscope, magnifiers).

DEFINITIONS

- Scuffing - To become scratched, chipped, or roughened by wear.
- Galling - To fret and wear away by friction.
- Scoring - A line (as a scratch or incision) made with, or as if made with, a sharp instrument.
- Spalling - To break oft chips, scales, or slabs.
- Polishing - To make smooth and glossy by friction.
- Erosion - To eat into or away by slow destruction of substance.
- Fretting - The action of wearing away, a worn or eroded spot.

SAMPLE SIZE

Hardness Testing

	Quantity
Piston Pins	2
Main Bearing and Engine Base	1
Rocker Arm Capscrews	4
Main Bearing Nut	4
Main Bearing Stud	2
Cylinder Liners	4
Air Start Valve Capscrew	4
Cylinder Head Studs	8
Connecting Rod Bolts	2 Short, 2 Long
Idler Gear	1

SAMPLE SIZE

(CONTINUED)

Alloy Separator

	Quantity
Cylinder Block	1
Piston Skirt	2
Piston Crown	2
Cylinder Liner	2
Main Bearing Cap	1
Engine Base	1
Head Studs	8
Connecting Rod Box Bolts	2 Short, 2 Long
Air Start Valve Capscrews	4
Piston Pins	2
Rocker Arm Capscrews	4
Cylinder Heads	2
Piston Crown Studs	2
Turbocharger Mounting Bolts	4

Transamerica Delaval

Inspection and Maintenance Report

Model DSRV-16-4 Serial Number 74033-2624

Owned and/or Operated By: Mississippi Power & Light Company

Installation/Site Location: Grand Gulf Nuclear Station Unit No. 1

Date _____

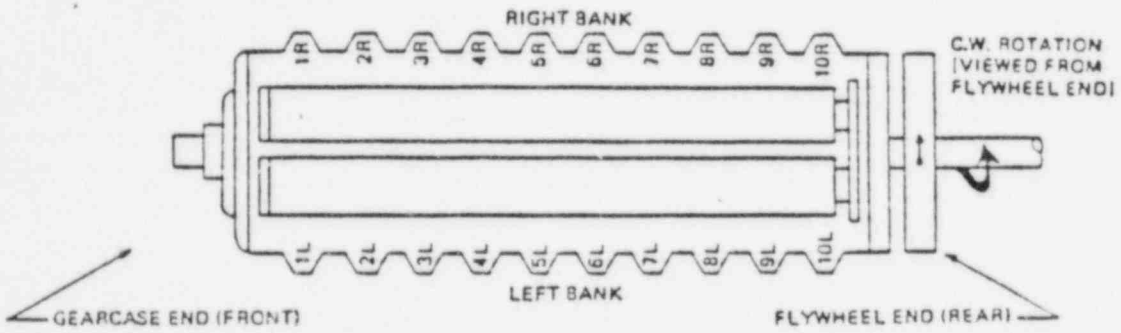
Transamerica Delaval Inc.
Engine and Compressor Division
550 85th Avenue, P.O. Box 2161
Oakland, California 94621

CRANKSHAFT ROTATION AND CYLINDER DESIGNATION.

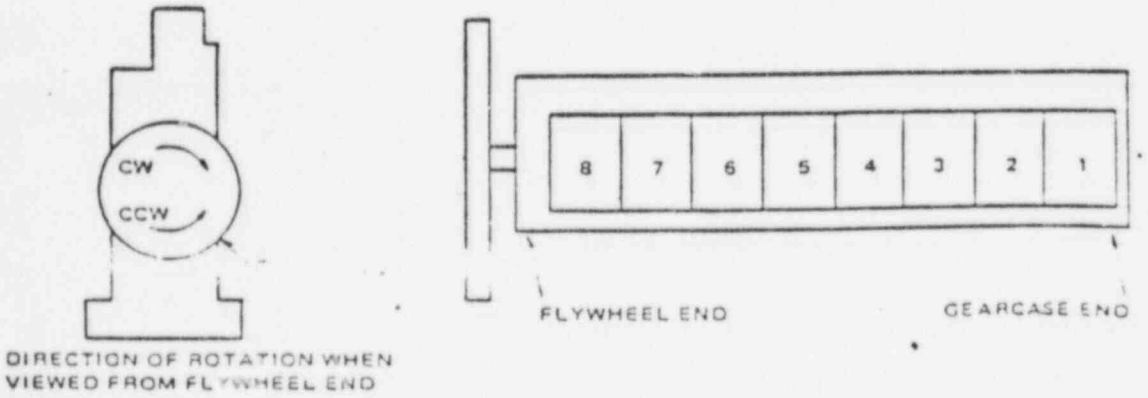
Crankshaft rotation for all four-valve cylinder head engines is determined by viewing the engine from the flywheel end. Cylinders are numbered beginning at the front, or gearcase end, on the opposite end of the engine from the flywheel. In the case of V-type engines, bank designation is determined as viewed from the flywheel end (see illustration). The exceptions to the above rules are as follows:

a. Model RV, two-valve head engines, Serial No. 67013 and up have rotation as viewed from the flywheel end, and bank designation as viewed from the gearcase end.

b. Model RV engines, Serial No. 66020 and prior have both bank designation and rotation as viewed from the gearcase end.



Model RV, Four-Valve-Head Engine



Model R Engine

INSTRUCTIONS FOR USE

These record sheets are intended to provide a means for recording and maintaining various data gathered during the course of maintenance, overhaul or repair of the "Enterprise" engine. Copies of this form, Transamerica Delaval Form E-267 are available.

To be of value in helping to determine both present and future repair and replacement needs, it is essential that all information be accurately recorded, and that the manner of filling out the forms be consistent. The following should be observed when using the forms.

a. Torque values should be recorded in foot pounds (ft-lbs) unless otherwise noted.

b. Clearances should be recorded in thousandths of an inch, i.e., 4 = 0.004 inch; 2 = .002 inch; 25 = 0.025 inch; 1.2 = 1.002 inch; 1.25 = 1.025 inch, etc. If other than inches are used, specify on each sheet the unit of measurement used.

c. Where significant, dial indicator readings should be recorded as + or - (plus or minus) readings. A reading not so specified will be assumed to be a plus (+) reading.

d. The heading of each form is filled out as follows:

(1) Component Group Title: Pre-printed with name of major component which is covered by that sheet.

(2) Parts Group No.: The three digit parts group number to which the component group belongs, and in which it may be found in the Parts Manual.

(3) Sheet: The identity of the record within a parts group.

(4) Page: The page number for a particular parts group/sheet.

(5) Customer: Fill in name of owner/operator of equipment.

(6) Equipment Location: Physical location of equipment, specified by name, position number or other descriptive term which may be appropriate to clearly identify the location.

(7) Engine Model: Complete model as appearing on nameplate.

(8) Serial Number: The number appearing on the engine nameplate. Usually consists of a five digit group, a dash and a four digit group.

(9) Customer's Designation: When owner or operator has a specific designation for the engine within his system which serves to identify it to him, enter this designation.

(10) Total Engine Hours: Hours since first startup.

(11) Hours Since Last Inspection: The time between the present Total Engine Hours reading at the last inspection.

(12) Date This Inspection: Self explanatory.

(13) References: Pre-printed. Indicates sources of instructions that should be used in conjunction with the inspection being performed.

e. Ensure that the proper designation is entered on all sheets where the position of the component being inspected serves to identify it. For instance, a separate sheet is needed for each bearing, each cylinder head, each piston and rod, etc. Identify these items.

TDI # 02-360A - SUMMARY

Part Name:	Cylinder Heads
	Intake and Exhaust Valves
	Intake and Exhaust Springs
Examination Areas:	Fire Deck-Headwall
	Nozzle Cavity
	Valve Seats
	Valves
	Springs
Examinations:	Ultrasonic
	Liquid Penetrant
	Magnetic Particle
	Visual
	Material Comparitor

Component Group Title	Parts Group No.	Sheet	Page
INTAKE and EXHAUST VALVES	360	2	1
Customer	Equipment Location		
Engine Model / Serial No.	Customer's Designation		
Total Engine Hours / Hours Since Last Inspection	Date This Inspection		
References: Instruction Manual, Section 6, Part B	Data Recorded By		

Cylinder No. / Bank

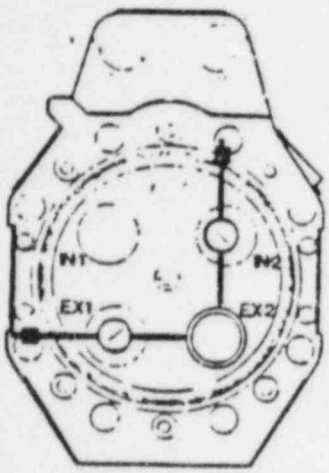


Figure 1

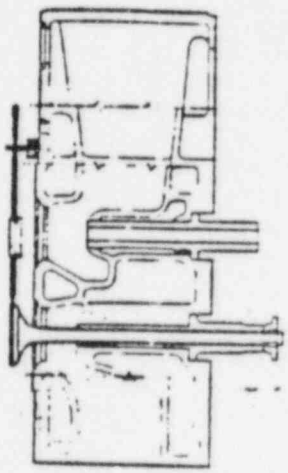


Figure 2

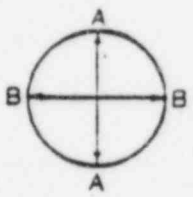


Figure 3

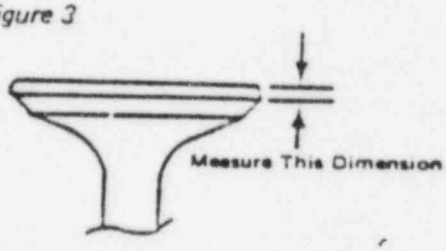


Figure 4

Valve-To-Guide Clearance

Measure by noting deflection on valve head while rocking valve in its guide. Remove wedges, retainers (or rotators) and springs. Lay cylinder head on its side with valve axis in the horizontal plane. Leave a wedge on valve stem and push valve out until stopped by wedge hitting guide (see Figure 2).

Position a dial indicator as shown in Figures 1 and 2 so that spindle of indicator is bearing against side of valve head on the A–A axis (see Figure 3). Zero the indicator, then apply sufficient pressure by hand at a point diametrically opposite the spindle to move the valve in the guide. Record this deflection. Repeat the process in the B–B axis and record all readings in the space provided below. See Figure 1 for valve identification (EX-1, IN-1, etc.).

Axis/Valve	EX-1	EX-2	IN-1	IN-2
A–A				
B–B				

Valve Head Thickness

Measure valve head thickness (Figure 4) with a micrometer and record in space below.

Valve	EX-1	EX-2	IN-1	IN-2
Thickness				

General Inspection

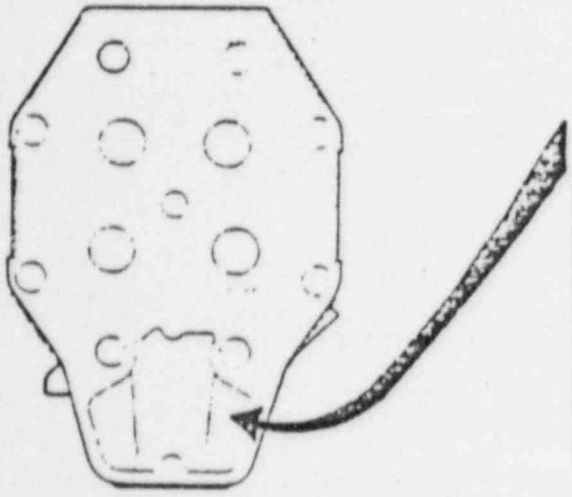
Inspect valve for general condition and not all abnormalities or other significant information below.

Transamerica Delaval

Inspection and Maintenance Record

Component Group Title	Parts Group No.	Sheet	Page
CYLINDER HEAD – Four Valve	360	1	1
Customer		Equipment Location	
Engine Model	Serial No.	Customer's Designation	
Total Engine Hours	Hours Since Last Inspection	Date This Inspection	
References: Instruction Manual, Section 6, Part 8		Data Recorded By	

Top View of Cylinder Head

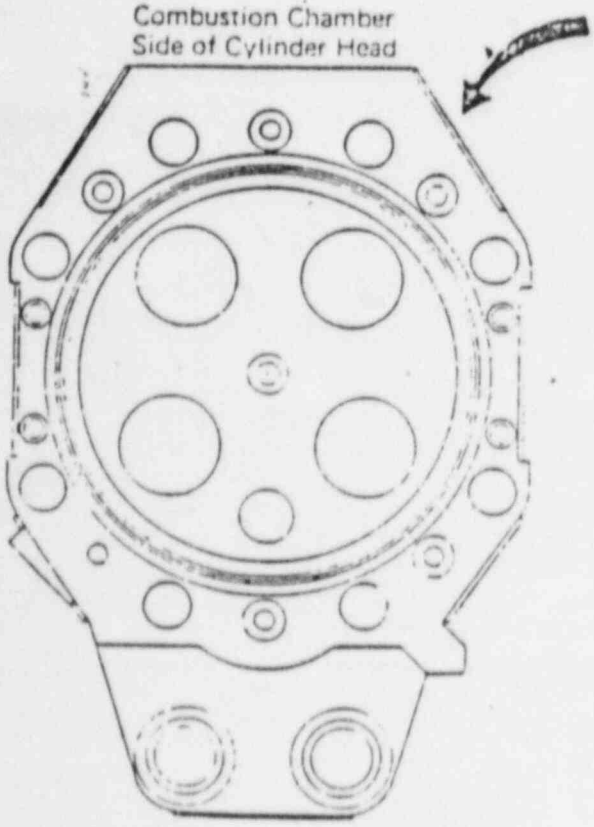


Cylinder No./Bank

Record all identification numbers and letters appearing in this location.

Identification Numbers

Combustion Chamber Side of Cylinder Head



Use diagram at left to sketch any abnormalities appearing on the cylinder head combustion surfaces and valve seats. Record comments relative to condition of cylinder head in spaces below.

Combustion Surfaces

Valve Seat Condition

Gasket Surfaces

Other (specify)

NDE INSPECTION CRITERIA

Component:	Cylinder Head
Examination:	Visual, procedure MVE-1, Rev. 1
Examination Areas:	Stellite surface of intake & exhaust valve seats. (See Fig. 1)
Acceptance Criteria:	The following are unacceptable: 1. Evidence of blow-by between valve and contact surface. 2. Nonuniform metallic appearing "ring" on the valve seat contact surface. 3. Cracks with less than 1/2 inch of space between them when the cracks are parallel to each other. 4. Rounded discontinuities greater than 1/16 inch. NOTE: Items 1 and 2 should be performed during disassembly, prior to cleaning.
Examination:	Liquid Penetrant, procedure M-PT-SR-1,2,Rev. 2.
Examination Area:	Stellite Surface of intake & exhaust valve seat. (See Fig. 1)
Acceptance Criteria:	The following are unacceptable: o Cracks with less than 1/2 inch of space between them when the cracks are parallel to each other.
Examination:	Fluorescent magnetic particle, procedure G.E.O. 21.A.2, Rev.4.
Examination Area:	Fire deck (See Fig. 2).
Acceptance Criteria:	The following are unacceptable: o Crack hot tear or seam

- o Linear indication greater than 1/4 inch.
- o Linear inclusions exceeding Degree 1-1C of ASTM E 125-63.
- o Shrinkage exceeding Degree II-1 of ASTM E 125-63.
- o Inclusion exceeding Degree III-1 of ASTM E125-63.
- o Porosity exceeding Degree V-1 of ASTM E125-63.

Examination: Ultrasonic, procedure M-TM-D-1, Rev.0.

Examination Area: Fire deck (See Fig. 3).

Acceptance Criteria: The following is unacceptable:

- o Wall thickness less than 0.4 inch.

Examination Area: Fuel nozzle cavity at two elevations, approximately one-third and two-thirds down in cavity from spring side. At each elevation scan the circumference of the cavity to detect the minimum wall thickness at that elevation. (See Fig. 3).

Acceptance Criteria: Record information for NPE Review and evaluation. No acceptance criteria established.

Component: Intake and Exhaust Valves

Examination: Visual, procedure MVE-1, Rev. 1.

Examination Area: Seat area of each valve head.

Acceptance Criteria: The following are unacceptable:

- o Nonuniform metallic appearing "ring" on valve contact surface, indicating inadequate seating.
- o Pitting, when associated with blow-by or errosion.
- o Scuffing or erosion.

Examination Area: Valve Stem Surface, Retaining Area, Rocker Arm Contact Surface.

Acceptance Criteria: The following are unacceptable:

- o Scuffing or scoring.
- o Cracking.

Examination Area: Complete circumference of the stem to stem friction weld. This area is located approximately 4 1/2 inches from the valve face and covered over with chrome. Fig. 7.

Acceptance Criteria: The following are unacceptable:

- o Cracks
- o Removal of chrome covering in excess of the following:
  1. Axial - 50% of stem length
  2. Circumferential - 50% of circumference

Examination: Liquid Penetrant, procedure M-PT-SR-1,2, Rev. 2

Examination Area: Blended Radius between valve head and valve stem.

Acceptance Criteria: The following are unacceptable:

- o Crack or linear indication.

Component: Valve Guides

Examination: Visual, procedure M-VE-1, Rev. 1.

Examination Area: BORE

Acceptance Criteria: The following are unacceptable:

- o Cracks
- o Scuffing or scoring
- o Conditions which are severe enough to cause drag when the valve is stroked through the bore (i.e., gouges, pits, build up)

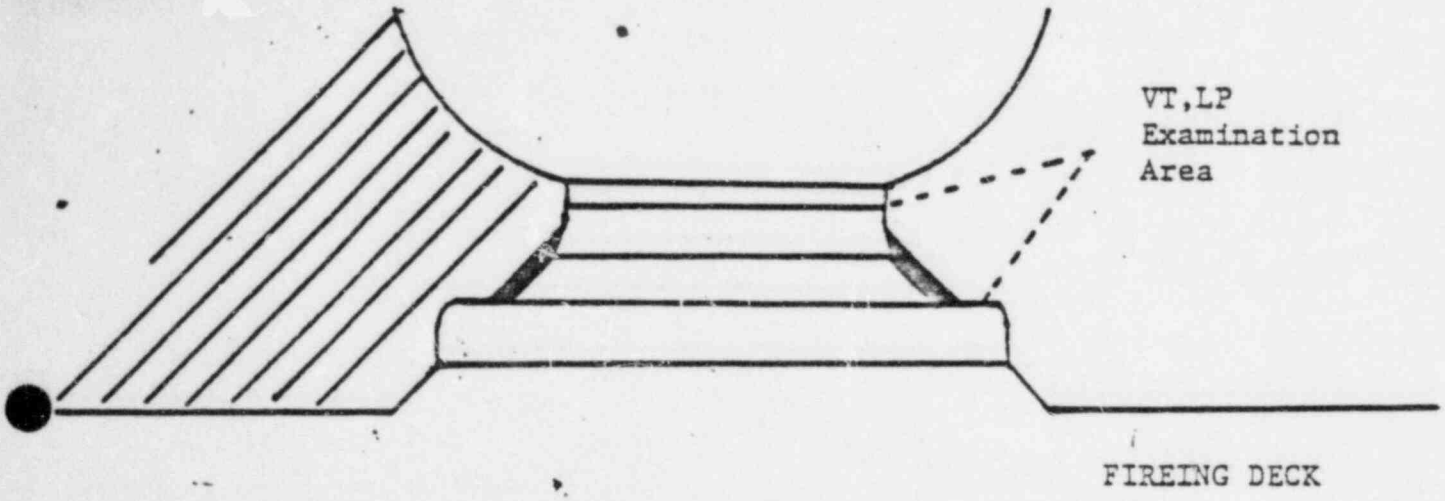
Component: Intake and Exhaust Valve Spring

Examination: Visual, procedure M-VE-1, Rev. 1.

Examination Area: Spring body.

Acceptance Criteria: The following are unacceptable:

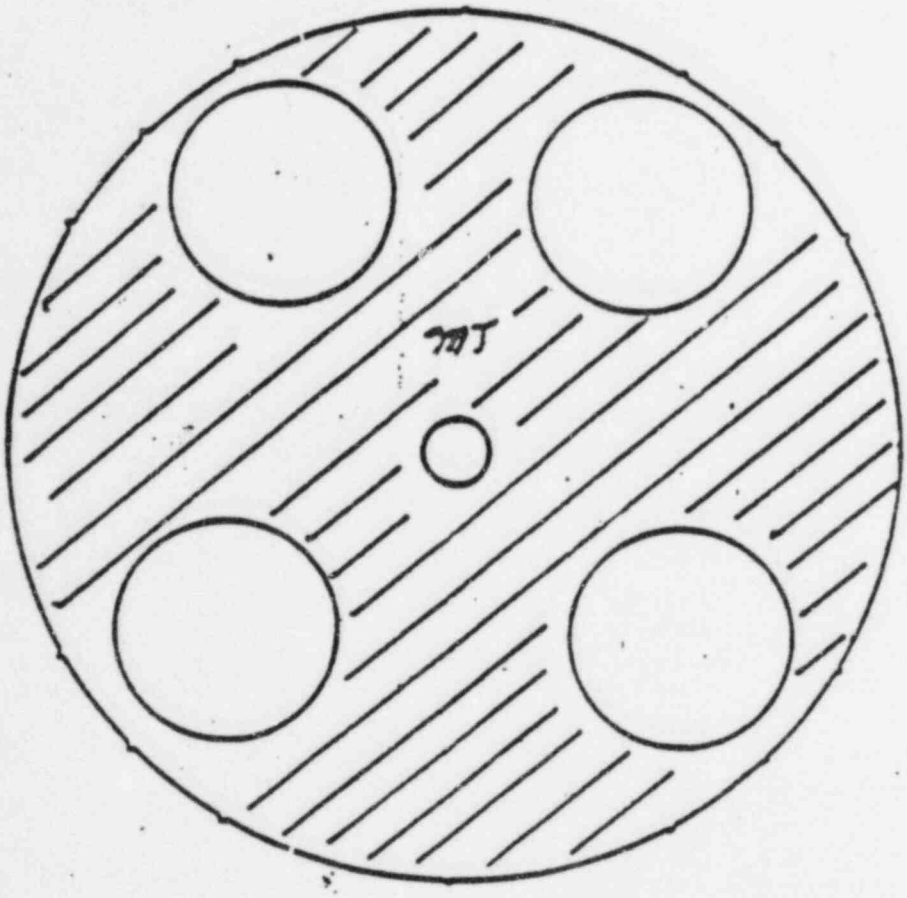
- Cracks
- Color codes other than black with white stripe down the side.



STELLITE SURFACE OF INTAKE & EXHAUST VALUE SEATS,
INCLUDING INTERFACE BETWEEN STELLITE & CARBON.

Fig. 1

EXHAUST

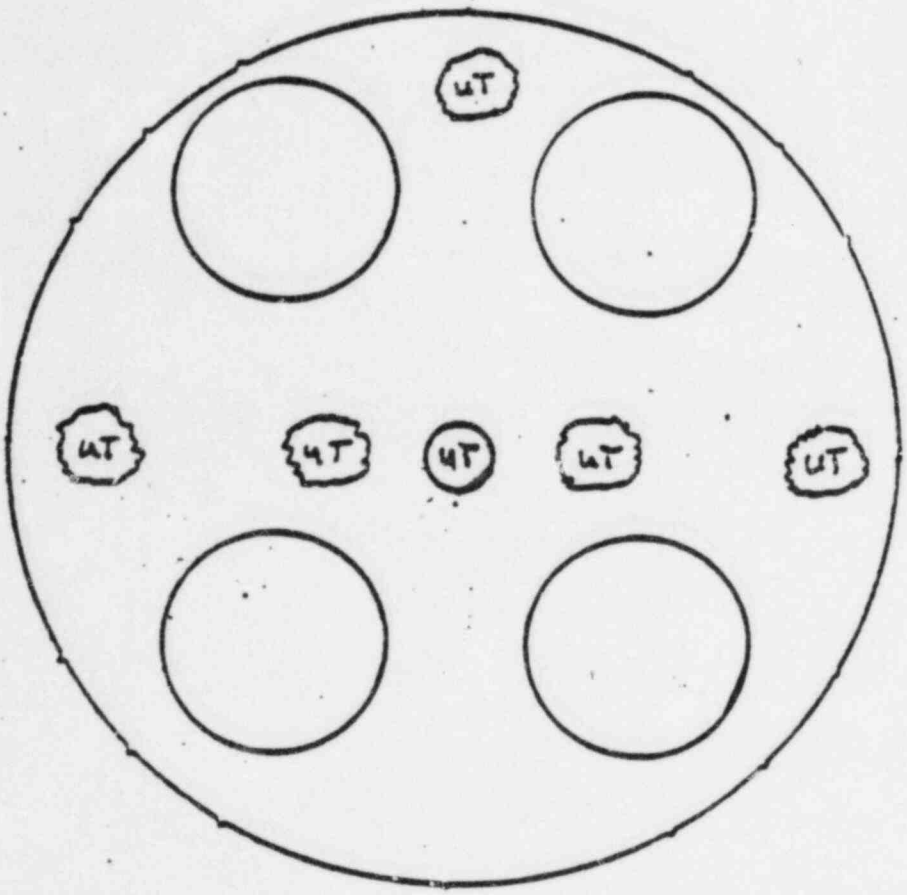


INTAKE

/// - FIRE DECK

Fig. 2

EXHAUST



INTAKE

HT — FIRE DECK

HT — FUEL NOZZLE CAVITY

Fig. 3

INTAKE AND EXHAUST VALVES

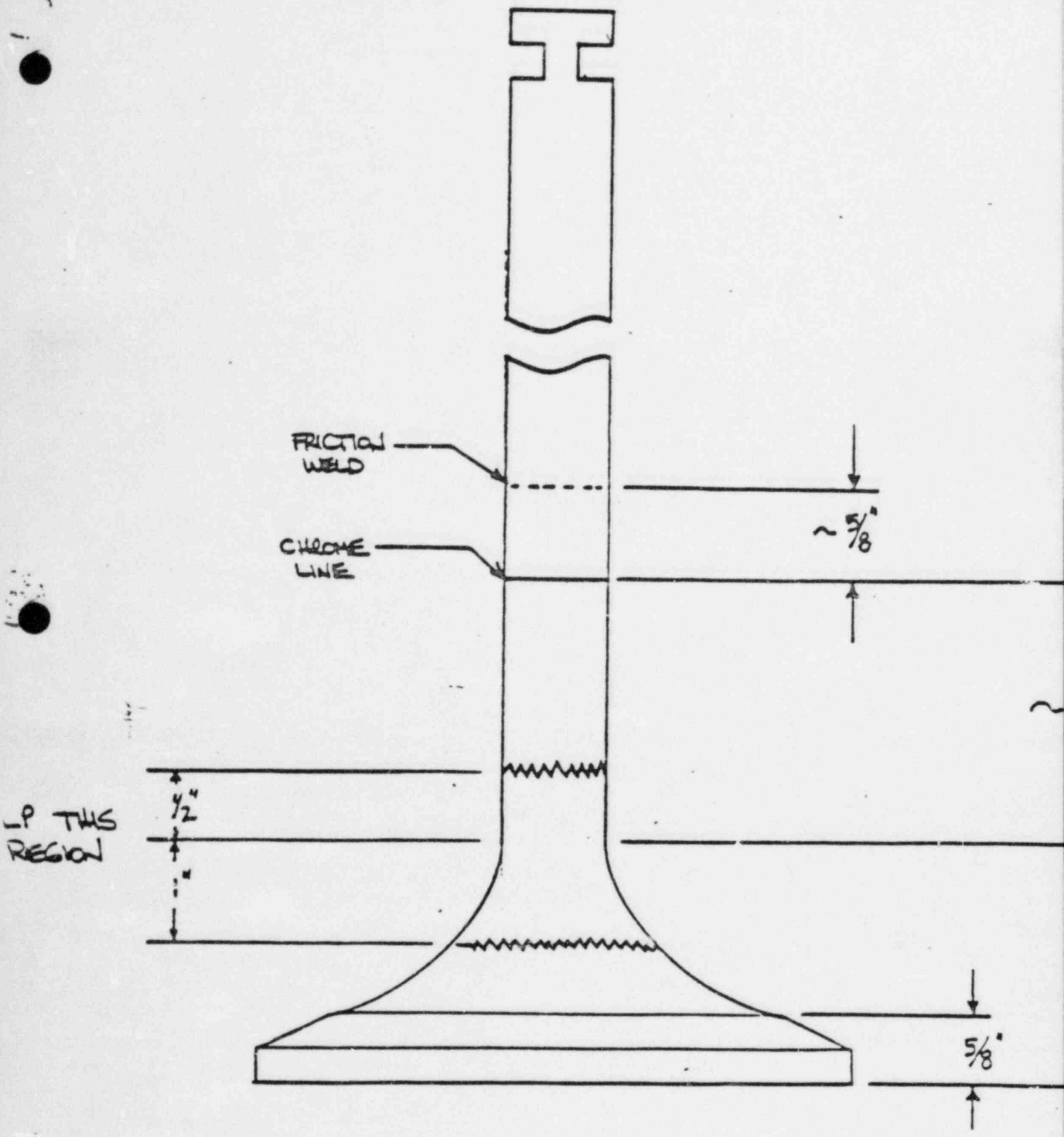


Fig. # 7

TDI # 02-305A - SUMMARY

Part Name:	Engine Base Assembly
Examination Areas:	Main Bearing Saddle Area Mating Surfaces
Examinations:	Liquid Penetrant
	Hardness
	Material Comparitor
	Visual

Component:	Engine Base Assembly
Examination:	Liquid Penetrant, M-PT-SR-1,2, Rev.
Examination Area:	Main bearing cap to engine base saddle mating surfaces, Fig. 8.
Acceptance Criteria:	The following relevant indications are unacceptable: o Relevant indications are those with major dimensions greater than 1/16 inch. o Linear indication greater than 1/16 inch long for material less than 5/8 inch thick, greater than 1/8 long for material from 5/8 inch thick to under 2 inches thick, and 3/16 inch long for materials 2 inches thick and greater. o Rounded indications with dimensions greater than 1/8 inch for thicknesses less than 5/8 inch, and greater than 3/16 inch for thicknesses 5/8 inch and greater. o Four or more indications in a line separated by 1/16 inch or less to edge. o Ten or more indications in any 6 inches of surface with the major dimension of this area not to exceed 6 inches taken in the most unfavorable orientation relative to the indication being evaluated.
Examination:	Visual, Procedure M-VE-1, Rev. 1.
Examination Area:	Mating surfaces of bearing cap and engine base assembly.
Acceptance Criteria:	Abnormal wear or fretting shall be rejected.
Examination:	Brinell Hardness Testing, Equotip Hardness Tester.
Examination Area:	Complete Stud and Nuts.
Acceptance Criteria:	NOTE: 7

Examination:	Material verification Technicorp Model 850/950 Pl WT Alloy Separator.
Examination Area:	Studs and Nuts.
Acceptance Criteria:	NOTE: 6

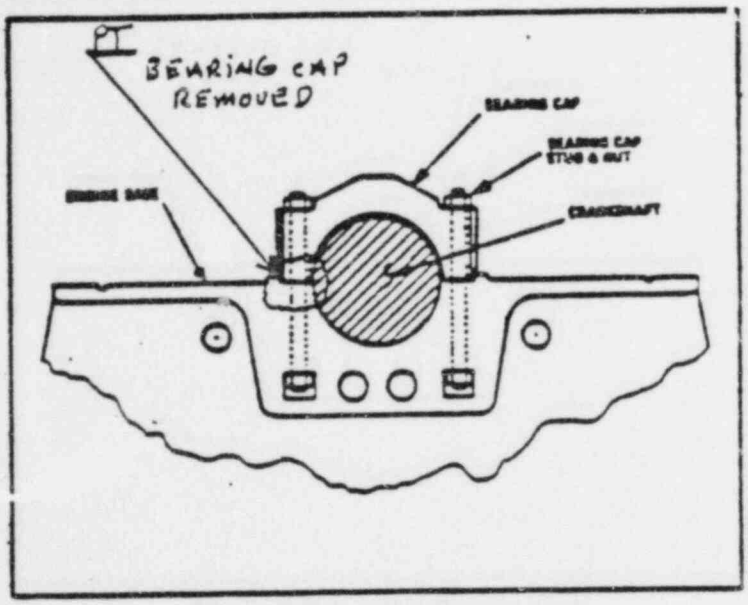


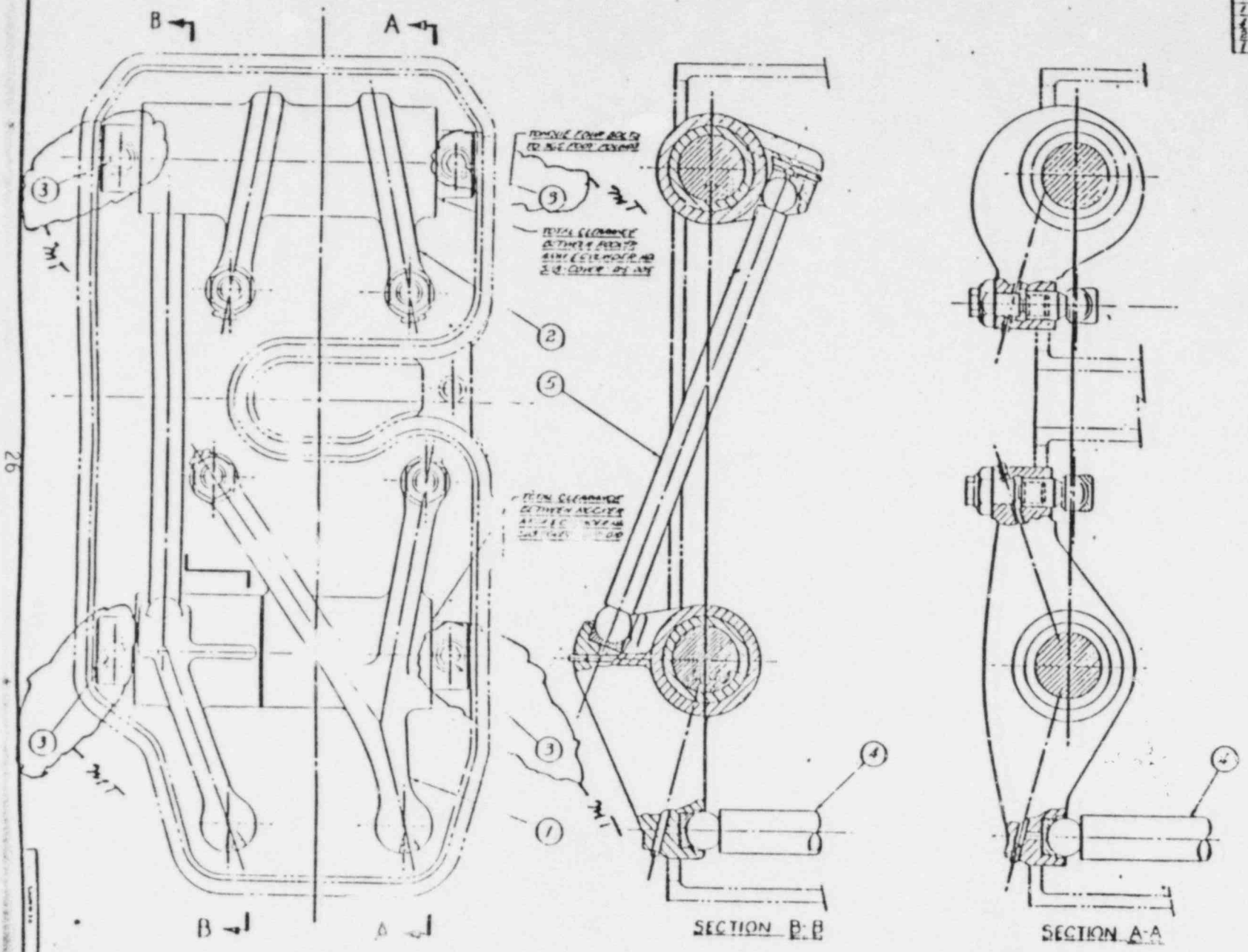
Figure 6-D-1. Main Bearing Cap

Fig. 8

TDI # 02-390G - SUMMARY

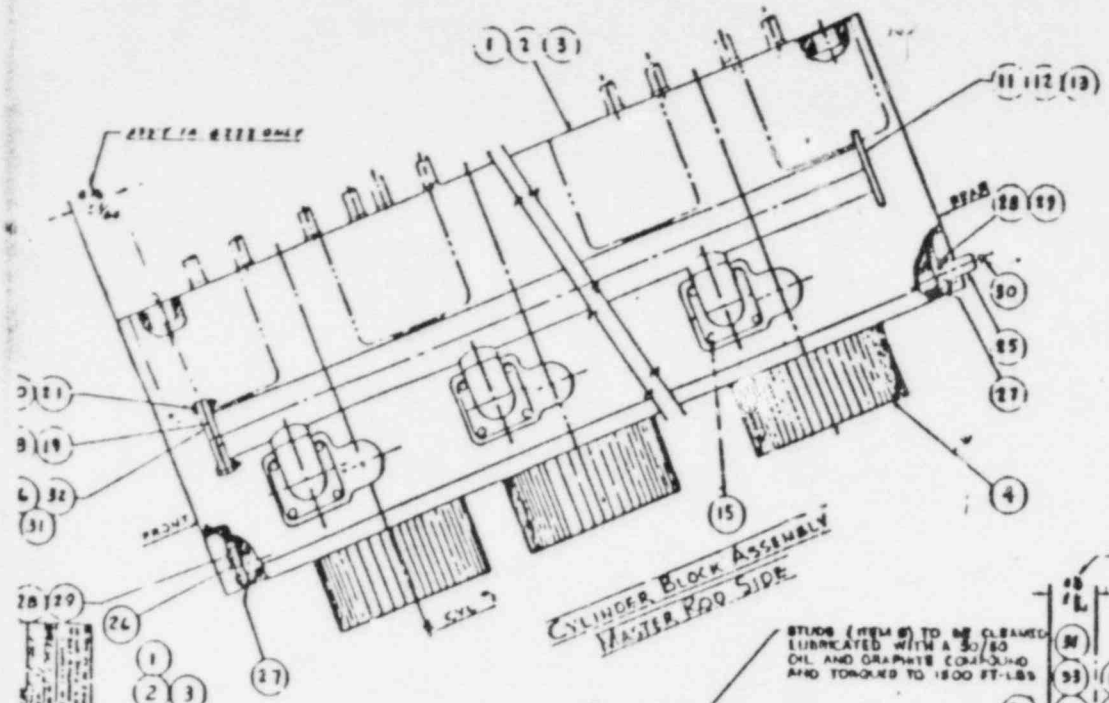
Part Name:	Rocker Arm Capscrews
	Rocker Arm Drive Studs (Rivets)
Examination Area:	Capscrews
	Rivets
Examinations:	Magnetic Particle
	Material Comparitor
	Hardness
	Visual

Component:	Rocker Arm Capscrews
Examination:	Magnetic particle, procedure G.E.O.21.A.2, Rev. 4.
Examination Area:	Complete capscrew surface
Acceptance Criteria:	The following are unacceptable: o Cracks o Signs of cross threading o Signs of galling o Any linear nonaxial indications
Examination:	Brinell Hardness Testing, Equotip Hardness Tester.
Examination Area:	Capscrew Head.
Acceptance Criteria:	NOTE: 7
Examination:	Material verification Technicorp Model 850/950 P1 WT Alloy Separator.
Examination Area:	Capscrew Head.
Acceptance Criteria:	NOTE: 6
Component:	Rocker Arm Drive Studs (Rivets)
Examination:	Visual, Procedure M-VE-1, Rev. 1.
Examination Area:	Rivet
Acceptance Criteria:	No movement of stud.

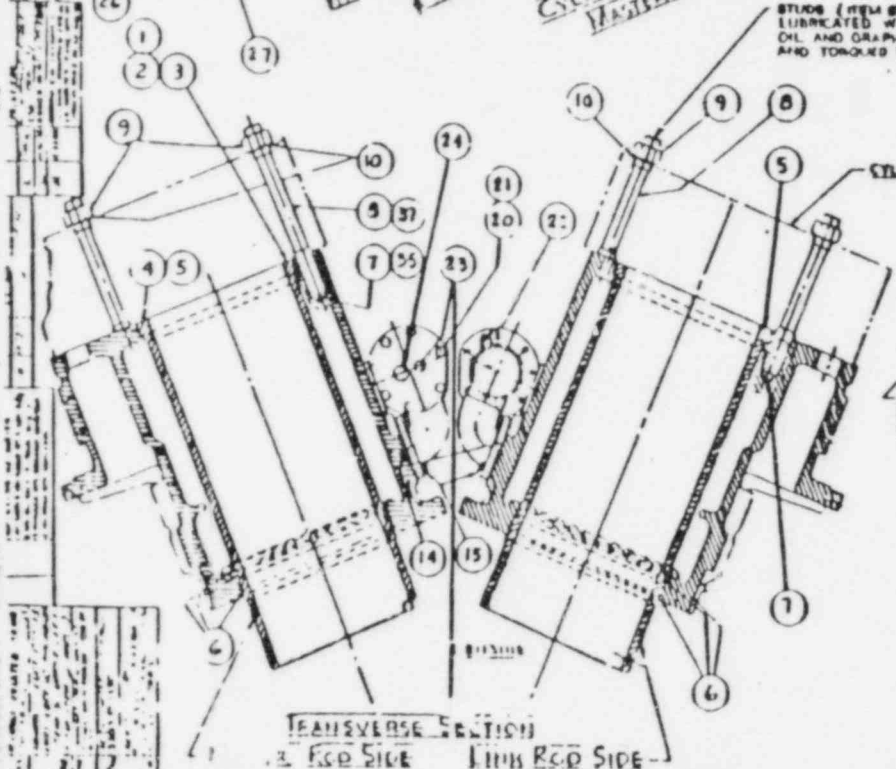

B
A
B
A
SECTION B-B
SECTION A-A

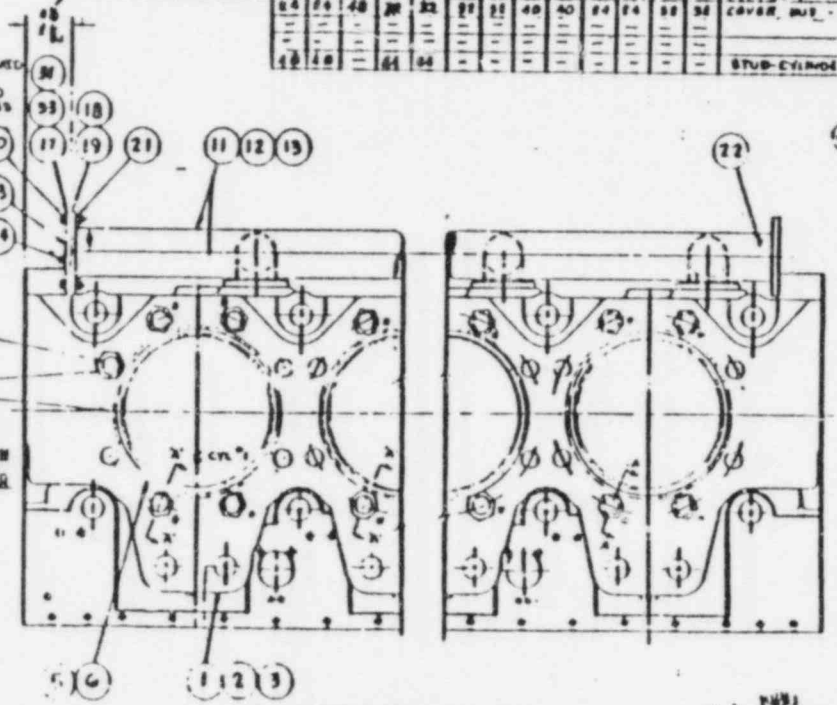
TDI # 02-315A - SUMMARY

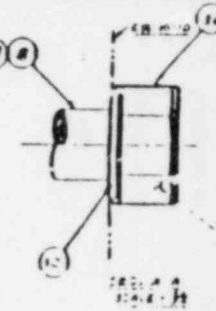
Part Name:	Cylinder Block
Examination Area:	Liner Landing
	Internal Cylinder Block Bore
	Head to Block Mating Surface
	Block Stud Hole Area
Examinations:	Visual
	Liquid Penetrant
	Dimensional



PART NAME	PART NO
BLOCK CYLINDER	02 315 01 AA
BLOCK CYLINDER	02 315 01 AB
BLOCK CYLINDER	02 315 01 AC
LINER CYLINDER	02 315 01 AA
LINER CYLINDER	02 315 01 AB
RING CYL LINER SEAL	11 015 00 AA
LOCKWASHER CYL HD STUD	02 305 01 AA
STUD - CYL HD	02 315 01 AA
NUT - CYL HD	11 305 01 AA
WASHER - CYL HD STUD	10 681
MANIFOLD - WATER	02 315 01 AA
MANIFOLD - WATER	02 315 01 AB
MANIFOLD - WATER	02 315 01 AC
BARREL MANIFOLD TOCK PIN	51 181 B
CAPSCREW - HEX HD	11 001 111
FLANGE - MANIFOLD END	02 315 01 AA
FLANGE - MANIFOLD END	02 315 01 AB
GASKET FLANGE TO MANIFOLD	02 315 01 AA
GASKET FLANGE TO MANIFOLD	02 315 01 AB
CAPSCREW - HEX HD	11 001 111
NUT HEX	11 305 01 AA
PIPE PLUG - SQ HD	11 005 00 A
PIPE PLUG - SQ HD	11 005 00 A
PIPE PLUG - SQ HD	11 005 00 A
PIPE - WATER DRAIN	51 181 B
FLANGE - BLIND	51 181 B
GASKET - FLANGE TO BLOCK	51 181 A
CAPSCREW - HEX HD	11 001 118
LOCKING CLIP	180 005
PIPE PLUG - SQ HD	11 005 00
FLANGE - MANIFOLD END	02 315 01 AA
FLANGE - MANIFOLD END	02 315 01 AB
FLANGE - MANIFOLD END	02 315 01 AC
COVER - CYL HD	11 005 00
STUD CYLINDER HEAD	02 315 01 AA







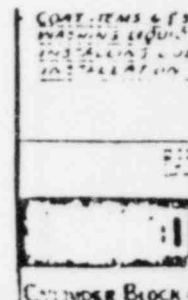
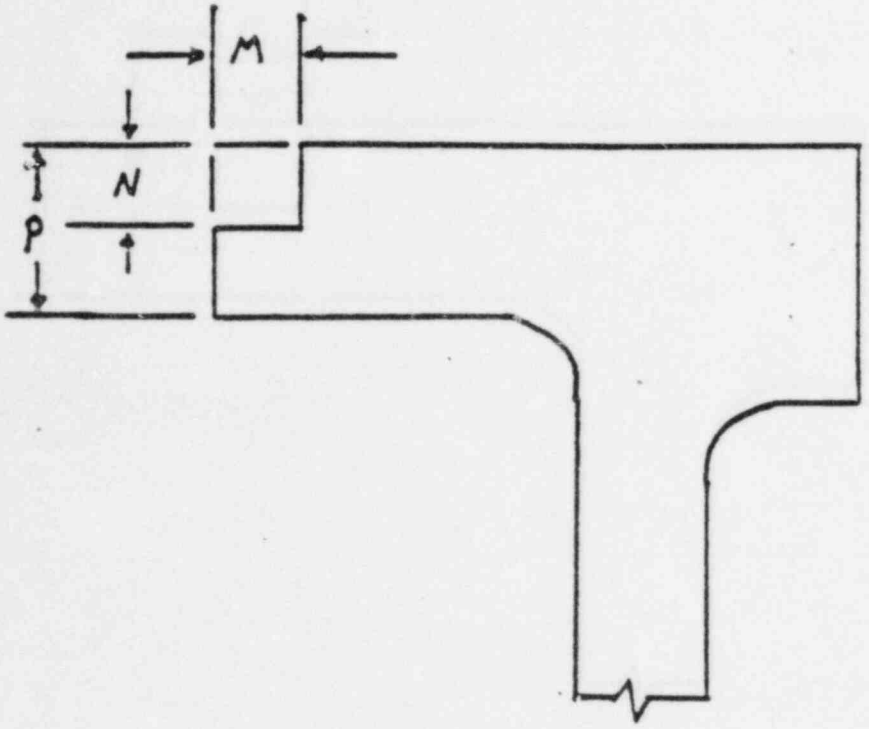
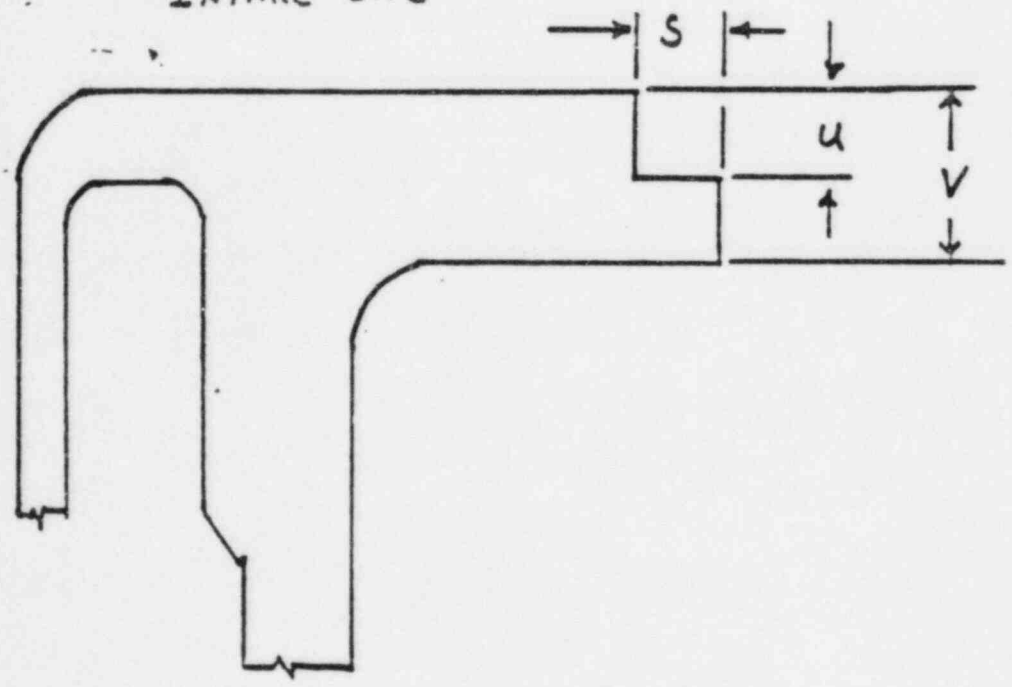


Fig 4

EXHAUST SIDE



INTAKE SIDE



Component: Cylinder Block

Examination: Visual, procedure M-VE-1, Rev. 1

Examination Area: Internal block bore, with liner removed.

Acceptance Criteria: The following are unacceptable:

- o Cracks.

Examination: Liquid Penetrant, procedure M-PT-SR-1,2, Rev. 2.

Examination Area: Cylinder block head mating surface and cylinder liner landing area, liner removed.

Acceptance Criteria: The following relevant indications shall be recorded for base line data and reported to NPE:

- o Relevant indications are those with major dimensions greater than 1/16 inch.
- o Linear indications greater than 1/16 inch long for material less than 5/8 inch thick, greater than 1/8 inch long for material from 5/8 inch thick to under 2 inches thick, and 3/16 inch long for materials 2 inches thick and greater.
- o Rounded indications with dimensions greater than 1/8 inch for thicknesses less than 5/8 inch and greater than 3/16 inch for thicknesses 5/8 inch and greater.
- o Four or more indications in a line separated by 1/16 inch or less edge to edge.

	o Ten or more indications in any 6 inches of surface with the major dimension of this area not to exceed 6 inches taken in the most unfavorable orientation relative to the indication being evaluated.
Examination:	Dimensional, procedure N/A.
Examination Area:	Cylinder liner landing area, P, N, M, S, U, V, Fig. 4.
Acceptance Criteria:	Record data and submit to NPE for evaluation. There are no acceptance standards.

TDI # 02-315-E - SUMMARY

Part Name:	Cylinder Head Studs
Examination Area:	Stud Body
Examinations:	Visual
	Hardness
	Material Comparitor

Component:	Cylinder Head Studs
Examination:	Visual, procedure M-VE-1. Rev. 1.
Examination Area:	Complete stud.
Acceptance Criteria:	The following are unacceptable: o Signs of cross threading. o Signs of galling. o Cracks on shank or within threaded portion. o Any linear nonaxial indications. NOTE: Record all visible identification numbers.

Examination:	Material Comparitor, using Technicorp Model 850/950 Mod P1 WT Alloy Separator.
Examination Area:	Cylinder head stud, head.
Acceptance Criteria:	NOTE: 6
Examination:	Brinell hardness testing, Equotip Hardness Tester.
Examination Area:	Cylinder head stud, head.
Acceptance Criteria:	NOTE: 7

TDI # 02-315C - SUMMARY

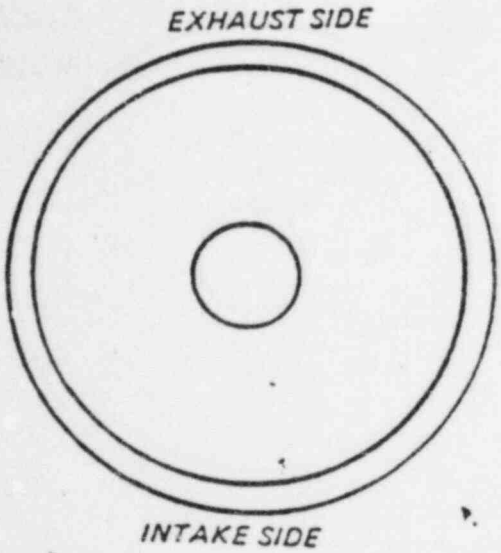
Part Name:	Cylinder Liners
Examination Area:	Cylinder Bore
Examinations:	Visual
	Dimensional
	Hardness
	Material Comparitor

Transamerica Delaval

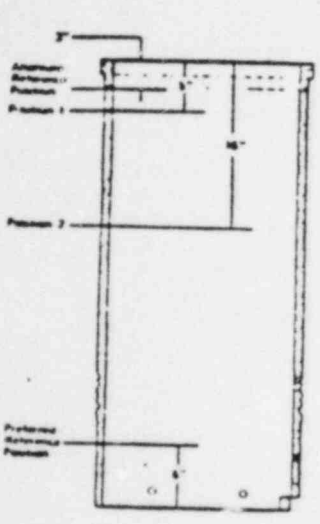
Inspection and Maintenance Record

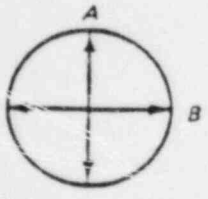
Component Group Title	Parts Group No.	Sheet	Page
CYLINDER LINERS	315	1	1
Customer	Equipment Location		
Engine Model / Serial No.	Customer's Designation		
Total Engine Hours / Hours Since Last Inspection	Date This Inspection		
References: Instruction Manual, Section 6, Part C	Data Recorded By		

Cylinder No./Bank _____



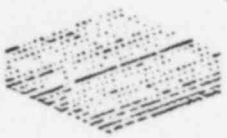
Indicate blemishes on interior surface of cylinder liner as seen from above.



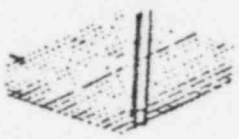


A = Inboard (exhaust) side

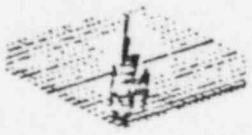
B = Flywheel End



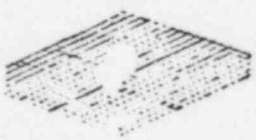
NORMAL CROSSHATCH



SCRATCHES – Long narrow grooves usu caused by foreign material. Crosshatch pattern runs through.



SCUFFING – Caused by piston and/or rin Can start below oil ring and run up throug upper compression ring travel area. Cross- hatch pattern cannot be seen.



BRIGHT SPOT – Bearing through crossha Can appear anywhere. Probable cause: He bearing by buildup above top ring land.

DIRECTIONS FOR TAKING MICROMETER READINGS:

1. Establish reference measurement and record. If piston is out of liner, or if liner i removed from block, use PREFERRED REFERENCE POSITION. If piston is installed in liner, use ALTERNATE REFERENCE POSITION. Take two readings 90 degrees apart (A and B).
2. Take readings at Position 1 and record.
3. Take readings at Position 2 and record.

	Before Honing		After Honing	
	A	B	A	B
Ref.				
1				
2				

Method of honing employed (i.e., glaze breaker/grit Sunnen hone/stone grit):

Remarks:

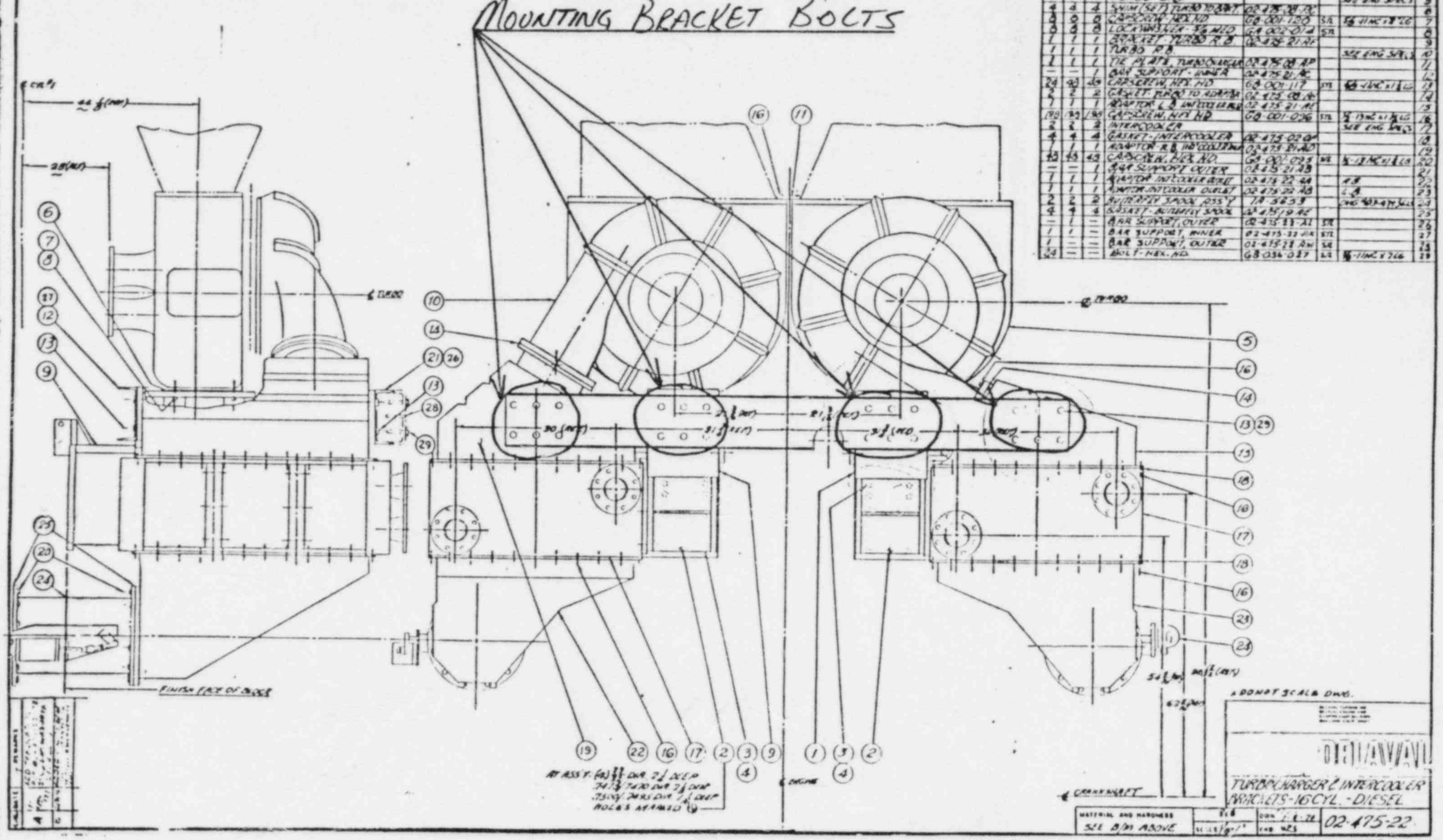
Component:	Cylinder Liners
Examination:	Visual, procedure M-VE-1, Rev. 1.
Examination Area:	Zone of piston travel, cylinder bore.
Acceptance Criteria:	The following are unacceptable: o Cracks o Scoring o Uneven wear in the cylinder liner. A polishing type wear around the liner for the full stroke of the piston is normal. o Evidence of internal bore being egg-shaped.
Examination Area:	Outside pilot diameter where it contacts the cylinder block.
Acceptance Criteria:	The following are unacceptable: o Corrosion o Spalling o Polishing o Erosion o Cracks
Examination:	Material Verification Technicorp Model 850/950 P1 WT Alloy Separator.
Examination Area:	Zone of piston travel, cylinder bore.
Acceptance Criteria:	NOTE: 6
Examination:	Brinell Hardness Testing, Equotip Hardness Tester.
Examination Area:	Out of the zone of piston travel cylinder bore.
Acceptance Criteria:	NOTE: 7

TDI # 02-475C - SUMMARY

Part Name:	Turbocharger
Examination Area:	Mounting Welds
	Bracket-Bolting
	Bracket and turbocharger mounting bolting
Examinations:	Visual
	Material Comparitor
	Torque Verification

Component:	Turbocharger Mountings Welds
Examination:	Visual, procedure M-VE-1, Rev. 1
Examination Area:	Jacket water piping between engine header and turbo, turbo to adapter, welds.
Acceptance Criteria:	The following are unacceptable: o Cracks o Leakage evidence at welds
Component:	Bracket-Capscrew, Hex and Turbocharger to Bracket-Capscrew, Hex
Examination:	Visual, procedure M-VE-1, Rev. 1.
Examination Area:	Capscrews
Acceptance Criteria:	The following are unacceptable: o Loose Parts o Cracks, integrity loss at capscrews.
Examination:	Torque Verification
Examination Area:	Capscrews
Acceptance Criteria:	Select four (4) bolts and verify that torque meets TDI's requirements.

QTY 23	QTY 22	QTY 21	PART NAME	PART NO.	MAT'L	REMARKS	ITEM
1	1	1	BRACKET-TURBO L.B.	02-475-21-AG			1
4	4	4	DOWEL-BRKT. TO BLOCK	108-001			2
24	24	24	CAPSCREW, HEX. HD.	68-001-143	STL	[illegible]	3
24	24	24	LOCKWASHER-¾ MED	6A-002-015	STL		4
1	1	1	TURBO L.B.			SEE ENG. SPECS	5
4	4	4	SHIM (SET) TURBO TO BRKT.	02-475-28-AC			6
8	8	8	CAPSCREW, HEX. HD.	68-001-120	STL	[illegible]	7
8	8	8	LOCKWASHER-⅝ MED	6A-002-014	STL		8
1	1	1	BRACKET-TURBO R.B.	02-475-21-AF			9
1	1	1	TURBO R.B.			SEE ENG. SPECS	10
1	1	1	TIE PLATE, TURBOCHARGER	02-475-08-AP			11
—	—	1	BAR SUPPORT-INNER	02-475-21-AC			12
24	48	48	CAPSCREW, HEX. HD.	68-001-117	STL	[illegible]	13
2	2	2	GASKET-TURBO TO ADAPTER	02-475-08-AF			14
1	1	1	ADAPTOR L.B. INTERCOOLER INLET	02-475-21-AE			15
198	198	198	CAPSCREW, HEX. HD.	68-001-036	STL	[illegible]	16
2	2	2	INTERCOOLER			SEE ENG. SPECS	17
4	4	4	GASKET-INTERCOOLER	02-475-02-AF			18
1	1	1	ADAPTOR-R.B. INTERCOOLER INLET	02-475-21-AD			19
43	43	43	CAPSCREW, HEX. HD.	68-001-035	STL	[illegible]	20
—	—	1	BAR SUPPORT OUTER	02-475-21-AB			21
1	1	1	ADAPTOR INTERCOOLER OUTLET	02-475-22-AA		R.B.	22
1	1	1	ADAPTOR INTERCOOLER OUTLET	02-475-22-AB		L.B.	23
2	2	2	BUTTERFLY SPOOL ASS'Y	TA-3633		[illegible]	24
4	4	4	GASKET-BUTTERFLY SPOOL	02-475-19-AE			25
—	1	—	BAR SUPPORT, OUTER	02-475-33-AI	STL		26
1	1	—	BAR SUPPORT, INNER	02-475-33-AK	STL		27
1	—	—	BAR SUPPORT, OUTER	02-475-33-AH	STL		28
24	—	—	BOLT-HEX. HD.	68-036-027	STL	[illegible]	29



DO NOT SCALE DWG.

MATERIAL AND HARDNESS: SEE B/M ABOVE

DELAVAL

TURBOCHARGER & INTERCOOLER BRACKETS-16 CYL.-DIESEL

02-475-22

Examination:	Material Comparitor, using Technicorp Model 850/950 mod P1 WT Alloy Separator.
Examination Area:	Capscrew head.
Acceptance Criteria:	NOTE: 6

TDI # 02-475C - SUMMARY

Part Name:	Turbocharger
Examination Area:	Stationary Nozzle Ring. Bearings.
Examination:	Liquid Penetrant
	Visual

Component:	Stationary Nozzle Ring
Examination:	Liquid Penetrant, Procedure, GEO 23.A.2, Rev. 682/-0.
Examination Area:	Stationary Nozzle Ring
Acceptance Criteria:	No Cracks
Component:	Bearings
Examination:	Visual, Procedure M-VE-1, Rev. 1.
Examination Area:	Accessible surfaces of bearings
Acceptance Criteria:	Evidence of adverse wear or cracking shall be rejected.

TDI # 02-340A - SUMMARY

Part Name:	Connecting Rod Boxes/Piston Pin Bushing
Examination Area:	Female threads in Rod Box
	External Mach. Rod Box Surface (Both Sides)
	Connecting Rod Bolts
	Piston Pin Bushing
Examination:	Liquid Penetrant
	Dimensional
	Visual
	Magnetic Particle
	Hardness
	Material Comparitor

Component:	Connecting Rod Box
Examination:	Magnetic Particle, procedure G.E.O. 21.A-2, Rev.4.
Examination Area:	Connecting rod box external machined surfaces, both sides.
Acceptance Criteria:	The following relevant indications are unacceptable:

- o Relevant indications are those with major dimensions greater than 1/16 inch.
- o Linear indications greater than 1/16 inch long for material less than 5/8 inch thick, greater than 1/8 inch long for material from 5/8 inch thick to under 2 inches thick, and 3/16 inch long for materials 2 inches thick and greater.
- o Rounded indications with dimensions greater than 1/8 inch for thicknesses less than 5/8 inch and greater than 3/16 inch for thicknesses 5/8 inch and greater.
- o Four or more indications in any 6 inches of surface with the major dimensions of this area not to exceed 6 inches taken in the most unfavorable orientation relative to the indication being evaluated.
- o Cracks, seams, laps, shrinkage.

Examination Area:	Connecting Rod Box Bolts
Acceptance Criteria:	The following are unacceptable:

- o Linear axial indications greater than 1 inch.
- o Any linear nonaxial indications.

Examination: Liquid Penetrant, procedure M-PT-SR-1,2, Rev. 2.

Examination Area: Sides and internal bore of the piston pin bushing Fig. 6., TDI part number 19.

Acceptance Criteria: The following are unacceptable:

- o Cracks or linear indications on piston pin bushing, bottom dead center ±15° from center of piston pin.

Examination Area: Connecting rod box bolt hole, radius at top and bottom of hole (2 holes are through holes and do not have a bottom radius).

Acceptance Criteria: No cracks.

Examination: Visual, procedure M-VE-1, Rev. 1.

Examination Area: Connecting Rod Bolts - Hex head, connecting rod to box bolt Fig. 6 TDI Part Number E 12.

Acceptance Criteria: The following is unacceptable:

- o Cross threading
- o Galling
- o Cracks
- o Any linear nonaxial indications

Examination Area: Rack Teeth Connection

Acceptance Criteria: The following is unacceptable:

- o Fretting.

Examination Area: Connecting Rod Box Female Threads, Fig. 6.

Acceptance Criteria: The following are unacceptable:

- o Cracks
- o Galling
- o Cross Threading

Examination:	Material Comparitor, using Technicorp Model 850/950 MOD PI WT alloy separator
Examination Area:	Connecting Rod Box
Acceptance Criteria:	NOTE: 6
Examination:	Brinell Hardness Testing, Equotip Hardness Tester
Examination Area:	Connecting Rod Box
Acceptance Criteria:	NOTE: 7

Component Group Title	Parts Group No.	Sheet	Page
CONNECTING ROD – Model RV-3 & RV-4 Engine	340	2	1

Customer		Equipment Location
Engine Model	Serial No.	Customer's Designation
Total Engine Hours	Hours Since Last Inspection	Date This Inspection
References: Instruction Manual, Section 6, Part C		Data Recorded By

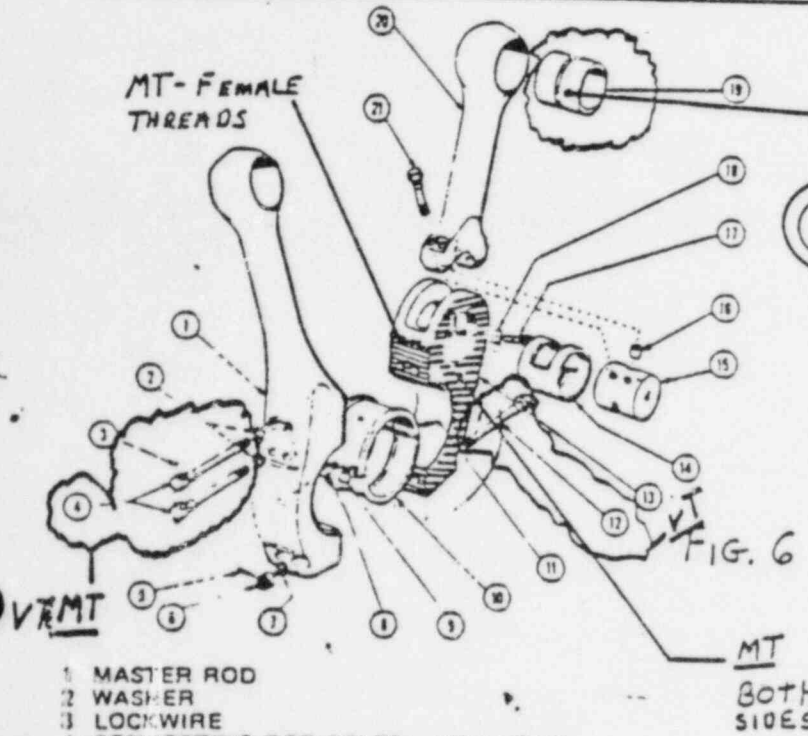
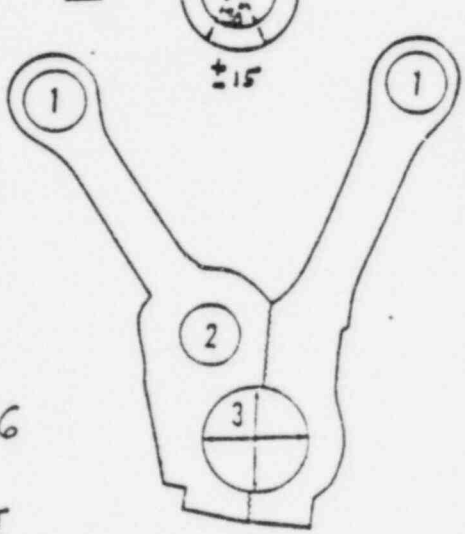


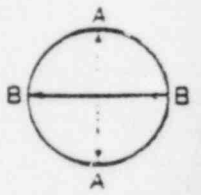
FIG. 6

1 MASTER ROD
2 WASHER
3 LOCKWIRE
4 CONNECTING ROD BOLTS – HEX HEAD
5 CUTTER PIN
6 SLOTTED HEAD NUTS
7 WASHER
8 CONNECTING ROD BEARING SHELL DOWEL
9 BEARING SHELL RETAINER RING
10 LOWER CONNECTING ROD BEARING SHELL
11 UPPER CONNECTING ROD BEARING SHELL
12 CONNECTING ROD TO BOX BOLT
13 CONNECTING ROD BOX
14 CONNECTING ROD BOX BUSHING
15 LINK PIN
16 LINK ROD TO PIN DOWEL
17 BOX BUSHING LOCK PIN
18 LOCKING CLIP
19 PISTON PIN BUSHING
20 LINK ROD
21 LINK ROD TO PIN BOLT

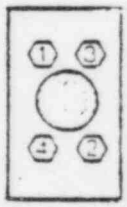


Measurement Locations

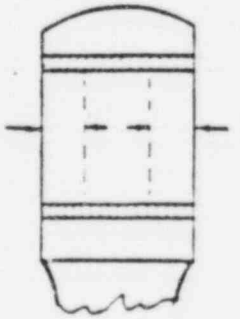
CYLINDER



Measurement Planes

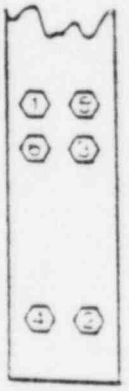


Link Rod To Pin Bol
Identification and
Tightening Sequence



Measure 2" in from outer edge

Piston Pin Bushing I.D.



Connecting Rod Bolts
Identification and
Tightening Sequence

Piston Pin Bushings

Measure inside diameter of link rod piston pin bushing with micrometer. Measure in vertical (A-A) and horizontal (B planes, 90° apart. Measure on both ends (gearcase and flywheel), two inches from end of bushing. Take same measurements on master rod piston pin bushing.

Step 1	Link Rod		Master Rod	
	A–A	B–B	A–A	B–B
Gearcase End				
Flywheel End				

Component Group Title	Parts Group No.	Sheet	Page
CONNECTING ROD – Model RV-3 & RV-4 Engine	340	2	2

Link Pin and Bushings

Measure inside diameter of link pin bushing with micrometer. Take measurements in vertical (A-A) and horizontal (B-B) planes, 90° apart. Measure on both ends (gearcase and flywheel), one inch from end of bushing. Measure outside diameter of link pin with micrometer. Measure on both ends, one inch in from end of pin in both vertical (A-A) and horizontal (B-B) planes.

Step 2	Link Pin Bushing I.D.		Link Pin Bushing O.D	
	A–A	B–B	A–A	B–B
Gearcase End				
Flywheel End				

Connecting Rod Bearing Bore

Reassemble connecting rod box to measure for out-of-round conditions at connecting rod bearing bore. Do not install bearings. Torque nuts to full torque value as shown in Instruction Manual. Measure connecting rod bearing bore inside diameter on both ends, one inch in from outer edges. Measure in vertical (A-A) and horizontal (B-B) planes. Take measurement (A-A) one-fourth inch in on opposite sides of split line as shown on sketch.

Step 3	Connecting Rod Bearing Bore I.D.	
	A–A	B–3
Gearcase End		
Flywheel End		

Non-Destructive Tests

Perform non-destructive test such as dye check on connecting rod box and all fasteners. Record results below.

Step 4

Bolt Torques

Record disassembly (breakaway) and assembly torques for connecting rod and link rod bolts. Identify bolts by number (see illustration). Torque bolts in sequence shown, applying torque in 20% lifts until final torque is reached. Refer to Instruction Manual for correct torque values.

Step 5A	Link Rod To Pin Bolt Torque (ft-lbs)			
	1	2	3	4
Disassembly				
Assembly				

Step 5B	Connecting Rod to Box & Connecting Rod Hex Head Bolts Torque (ft-lbs)					
	1	2	3	4	5	6
Disassembly						
Assembly						

TDI # 02-340B - SUMMARY

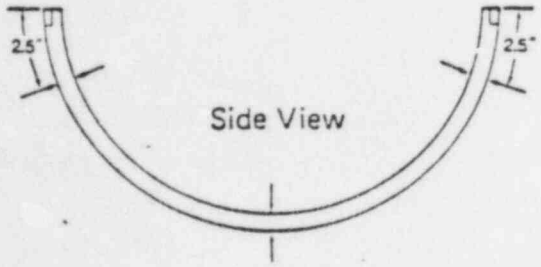
Part Name:	Connecting Rod Bearing Shells
Examinations:	Visual
	Dimensional
	Radiographic
Examination Area:	Complete shells

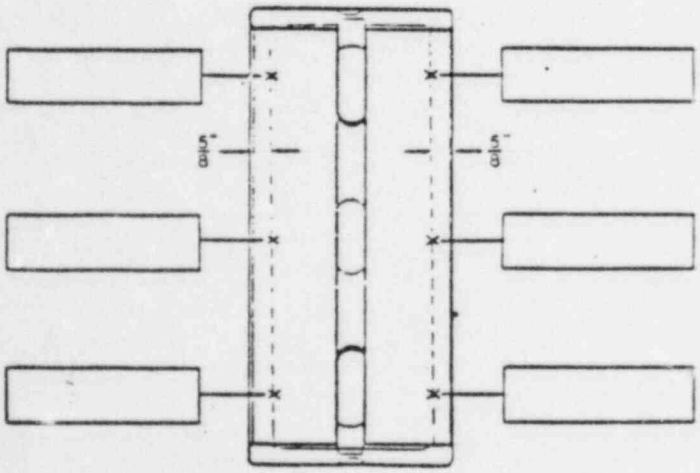
Transamerica Delaval

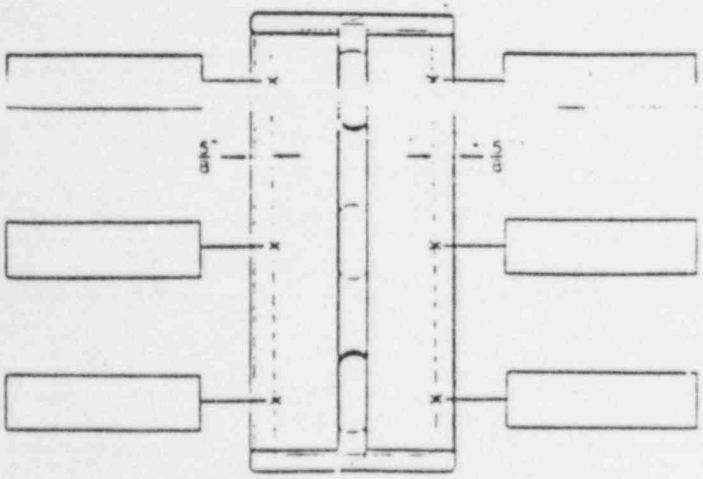
Inspection and Maintenance Record

Component Group Title	Parts Group No.	Sheet	Page
CONNECTING ROD BEARING SHELLS	340	1	1

Customer		Equipment Location
Engine Model	Serial No.	Customer's Designation
Total Engine Hours	Hours Since Last Inspection	Date This Inspection
References: Instruction Manual, Section 6, Part C		Data Recorded By







Bearing Shell Position _____

Record manufacturer's data as it appears on bearing shell.

Upper Shell
Lower Shell

Measure each bearing shell in six positions (marked "X" on drawings to the left), and record measurements in boxes by each measurement position. Use a ball micrometer.

Sketch bearing surface conditions—note any abnormalities.

Perform non-destructive dye check on all surfaces, including sides and ends of both shells. Note results below.

Results
Remarks

Bearings reused? Yes No

Component:	Connecting Rod Bearing Shells, Upper and Lower.
Examination:	X-Ray, Procedure GEO-3.20.A.1, Rev. 0 with Amendment 2 & 3.
Examination Area:	Upper Bearing Shell, Fig. 5: 0.050 inch area, .4 inches inward from sides to a point 1.4 inches inward from the side, extending circumferentially 2.5 inches on either side of center, this is the critical area. 0.250 inch area, remainder of bearing Lower Bearing Shell: 0.250 inch area, all of bearing
Acceptance Criteria:	The following are unacceptable, based on 3/4 inch reference radiographs of ASTM E-155, for aluminum.

	UPPER BEARING 0.050 AREA	UPPER & LOWER BEARING 0.250 AREA
GAS HOLES	0.050 diameter	Grade 5
GAS POROSITY (ROUNDED)	Grade 5	Grade 7
GAS POROSITY ELONGATED	Grade 3	Grade 5
SHRINKAGE SPONGE	Grade 3	Grade 4
FOREIGN MATERIAL LESS DENSE	0.050 diam.	Grade 3
FOREIGN MATERIAL MORE DENSE	0.050 diam.	Grade 4
CRACKS	unacceptable	unacceptable
SHRINKAGE CAVITY	unacceptable	.250

NOTE: MOTTLING/SEGREGATION AND MICRO SHRINKAGE SHALL NOT BE EVALUATED FOR REJECTION.

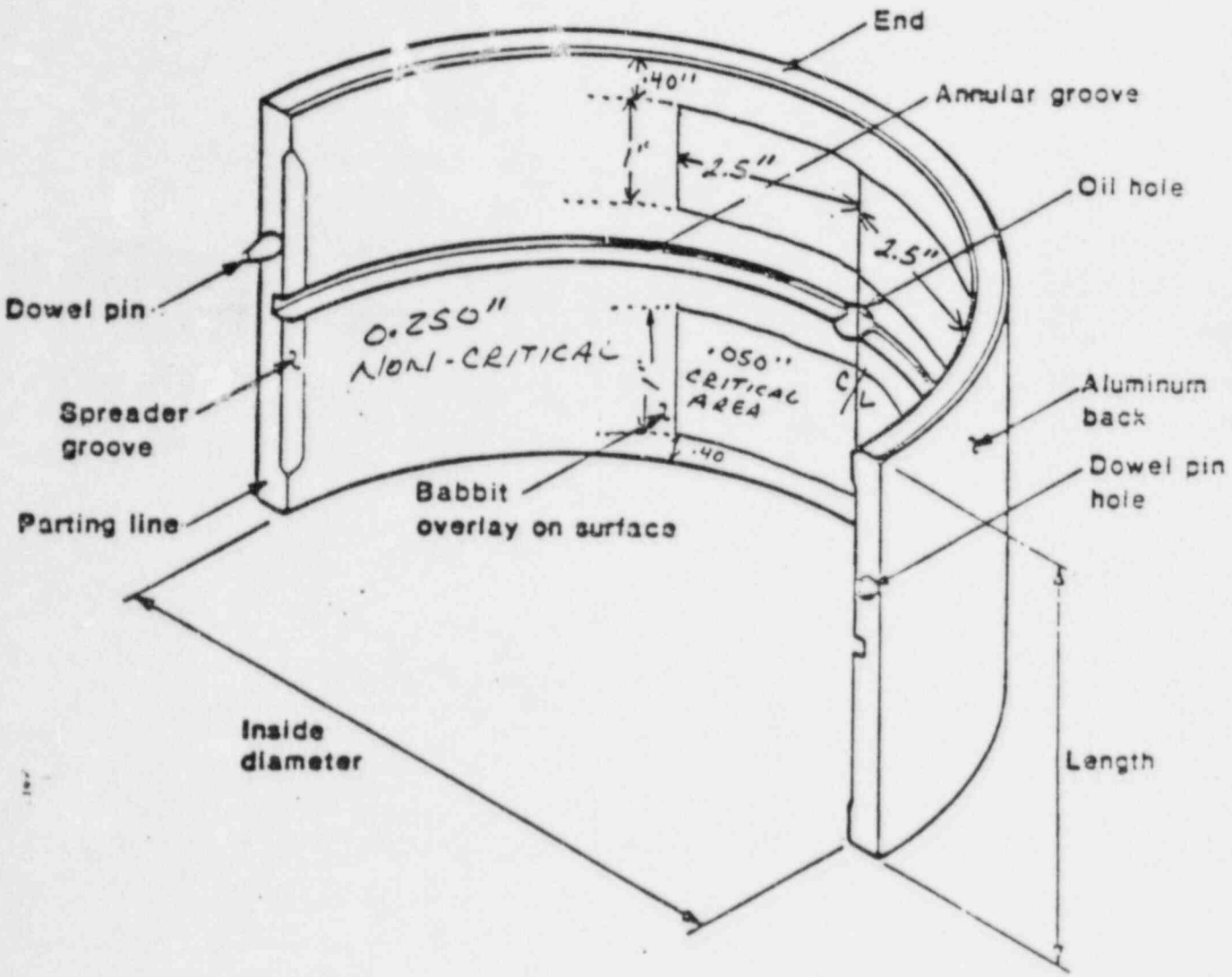


FIG. 5

Connecting rod bearing shell design and nomenclature (schematic).

TDI # 02-340C - SUMMARY

Part Name:	Piston/Crowns/Studs
Examination Areas:	Crown Fire Deck
	Piston Stud Boss Area
	Stud Body
Examinations:	Magnetic Particle
	Dimensional
	Material Comparitor
	Hardness

Transamerica Delaval

Inspection and Maintenance Record

Component Group Title	Parts Group No.	Sheet	Page
PISTONS – Two Piece	341	1	1

Customer		Equipment Location
Engine Model	Serial No.	Customer's Designation
Total Engine Hours	Hours Since Last Inspection	Date This Inspection
References: Instruction Manual, Section 6, Part C		Data Recorded By

Cylinder No. _____

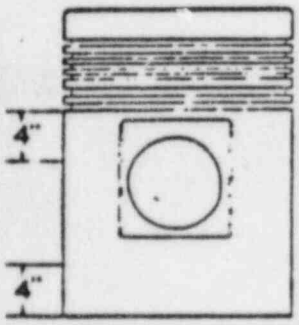


Fig. A Side View

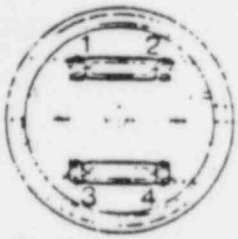


Fig. B Bottom View

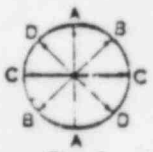


Fig. C

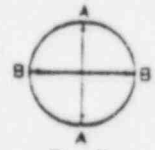


Fig. D

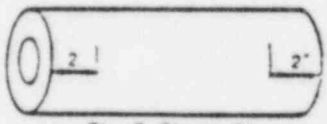


Fig. E Piston Pin

1. Measure piston skirt Outside Diameter and record dimensions below. Measure at two locations, 4 in. below bottom ring groove and 4 in. above bottom of skirt (see Fig. A). Measure four positions (A-A, B-B, C-C, D-D) in each location (see Fig. C).

Position	A-A	B-B	C-C	D-D
Upper				
Lower				

2. Measure piston pin Outside Diameter at two locations, 2 in. from each end (see Fig. E). Measure two positions (A-A, B-B) in each location (Fig. D).

Position	A	B
Forward End		
Aft End		

3. Measure piston pin bore in piston in two positions (A-A, B-B) in each end of bore (see Fig. D).

Position	A	B
Forward End		
Aft End		

4. Record disassembly (breakaway) torque and assembly torque of piston crown stud nuts (see Fig. B).

Position	1	2	3	4
Disassembly				
Assembly				

5. Note condition of O-ring, piston pin plug and general condition of piston.

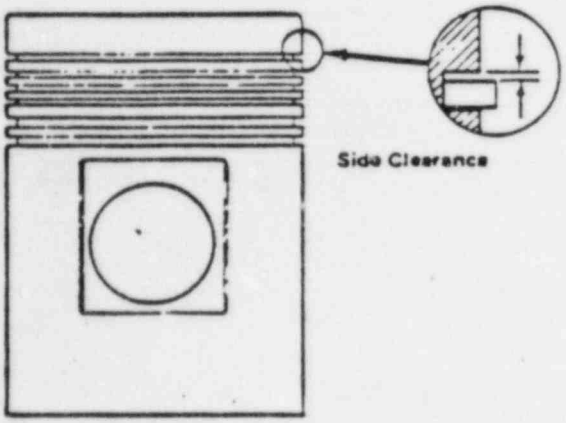
Transamerica Delaval

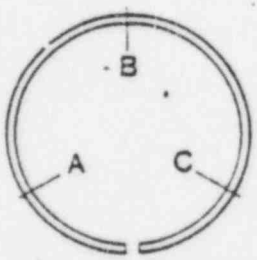
Inspection and Maintenance Record

Component Group Title	Parts Group No.	Sheet	Page
PISTON RINGS	341	2	1

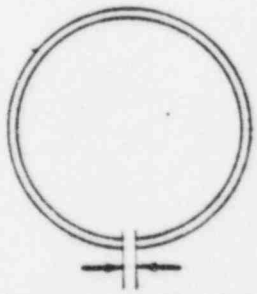
Customer		Equipment Location
Engine Model	Serial No.	Customer's Designation
Total Engine Hours	Hours Since Last Inspection	Date This Inspection
References: Instruction Manual , Section 6, Part C		Data Recorded By

Cylinder No./Bank





Locations for taking side gap clearances



Gap measurement with ring in cylinder liner at one of the reference positions shown on Sheet 315-1.

1. Measure piston ring side clearance in groove with feeler gauge. Measure each ring in three locations, 120 degrees apart. Record results below.
2. Remove rings from piston for cleaning and measurement of end gap clearance. Refer to Instruction Manual and Inspectio and Maintenance Record Sheet 315-1 for the proper procedure. Record gap and percent ring face contact.
3. If new rings are installed, note reasons in "Remarks" below.
4. If new rings are installed, record end gap and side clearance in grooves.

	Old (Removed) Rings					New (Replacement) Rings			
	Side Clearance			End	% Face	Side Clearance			End
Ring	A	B	C	Gap	Contact	A	B	C	Gap
1 Top Compression									
2 Top Compression									
3 Intermediate Compression									
4 Intermediate Compression									
5 Oil Control									
6 Oil Control									

Remarks

Component:	Piston Pins
Examination:	Visual, procedure M-VE-1, Rev. 1.
Examination Area:	Piston Pins wear surface.
Acceptance Criteria:	The following are unacceptable: o Cracking. o Signs of wear other than polishing. o Signs of scoring. o Signs of chrome plating being chipped.
Examination:	Brinell Hardness Testing, Equotip Hardness Tester.
Examination Area:	End surface of pins.
Acceptance Criteria:	NOTE: 7
Examination:	Material comparitor using Technicorp Model 850/950 Mod P1 WT Alloy Separator.
Examination Area:	End surface of pins.
Acceptance Criteria:	NOTE: 6

Component: Piston Crowns

Examination: Magnetic particle, procedure G.E.O.21. A-2, Rev. 4.

Examination Area: Complete firing surface, stud boss area.

Acceptance Criteria: The following are unacceptable:

- o Crack, hot tears or seam
- o Linear indications greater than 1/4 inch
- o Linear inclusions exceeding Degree 1-iC of ASTM E 125-63
- o Shrinkage exceeding Degree II-1 of ASTM E 125-63
- o Inclusion exceeding Degree III-1 of ASTM E 125-63
- o Porosity exceeding Degree V-1 of ASTM E 125-63

Component: Piston Skirt.

Examination: Magnetic Particle, procedure G.E.O. 21. A-2, Rev. 0

Examination Area: Machined bolt flat area on the inside of the piston skirt and adjoining radius's.

Acceptance Criteria: The following are unacceptable:

- o Cracks or hot tears.
- o Linear indications greater than 3/16 inch long in the stud hole flat area, or in the adjoining radius's
- o Rounded indications with dimensions greater than 3/16 inch.
- o Four or more rounded indications in a line separated by 1/16 of an inch or less edge to edge.

Component:	Piston Crown Studs
Examination:	Magnetic Particle, procedure G.E.O. 21. A.2, Rev. 4.
Examination Area:	Complete stud body. (Accessible surfaces, i.e., bolt design).
Acceptance Criteria:	The following are unacceptable: o Any linear nonaxial indications
Examination:	Visual, procedure M-VE-1, Rev.1
Examination Area:	Complete Stud Body
Acceptance Criteria:	The following are unacceptable: o Signs ot cross threading. o Signs of galling. o Cracks on shank or within threaded portion.

Component: Piston Rings - Deleted.

TDI # 02-310A - SUMMARY

Part Name:	Crankshaft
Examination Area:	Main Journals 4, 6, & 8 around oil holes. Connecting Rod Throws.
Examination:	Dimensional
	Visual
	Liquid Penetrant

Component:	Crankshaft
Examination:	Visual, Procedure M-VE-1, Rev. 1.
Examination Area:	Main Journals 4, 6, & 8 around oil holes.
Acceptance Criteria:	Evidence of abnormal wear or signs of distress shall be cause for rejection.
Examination:	Liquid Penetrant, Procedure PT-SR-1, 2, Rev. 2.
Examination Area:	Main Journals 4, 6, & 8 around oil holes.
Acceptance Criteria:	Cracks are unacceptable.
Examination:	Dimensional
Examination Area:	Radius of oil holes on main journals 4, 6, & 8.
Acceptance Criteria:	None, report radius dimensions to NPE for evaluation.
Examination:	Visual, procedure M-VE-1, Rev. 1.
Examination Area:	Connecting Rod Throws.
Acceptance Criteria:	Evidence of abnormal wear, scoring or cracks shall be cause for rejection.

Transamerica Delaval

Inspection and Maintenance Recor

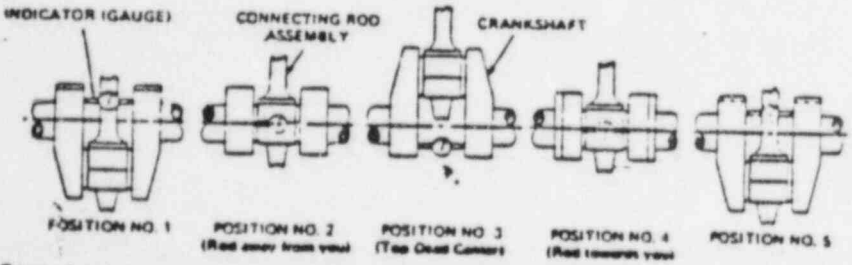
Component Group Title	Parts Group No.	Sheet	Page
CRANKSHAFT – Web Deflection and Thrust Clearance	310	1	

Customer		Equipment Location
Engine Model	Serial No.	Customer's Designation
Total Engine Hours	Hours Since Last Inspection	Date This Inspection
References: Instruction Manual, Section 6, Part D		Data Recorded By

~~Measure with a dial indicator while engine is hot, i.e., within 4 hours of shutdown.~~ Record oil temperature in sump tank or engine base, as appropriate. If connecting shaft is solidly coupled to flywheel and engine is grouted on a concrete foundation, desired deflection in position No. 3 is zero to plus (+) one thousandth of an inch in all cranks except the one adjacent to the flywheel. This should be minus 0.0005 inch to allow for distortion of the foundation. If mounted on a steel foundation, compensation for thermal distortion will be based on location and temperatures of fuel and oil tanks adjacent to foundation.

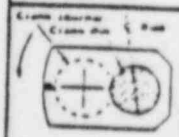
If deflection in any crank exceeds 0.003 inch, corrective action must be taken. Also, if total deflection in any two adjacent cranks exceeds 0.003 inch corrective action must be taken. Example: A +0.002 in. reading in any crank with a –0.002 in. in the next adjacent crank equal a total of 0.004 in. deflection between these adjacent cranks. The exception will be in the case of engines with a flexible coupling between the flywheel and the connecting shaft which have deflection in excess of 0.003 in. at Postion 3 in the crank adjacent to the flywheel. In engines with solidly coupled shafting, excessive deflection at Positions 2, 3 or 4 in the crank adjacent to the external shafting usually indicates misalignment between connecting shaft and crankshaft.

Set deflection gauge at zero at Position 1, and turn crankshaft in direction of normal rotation. Position 1 for placing deflection gauge is 15° after bottom center for all inline engines, and 52° after vertical bottom center for V-type engines. Models HV, HVA, and GVB engines are positioned 38° after vertical bottom center.



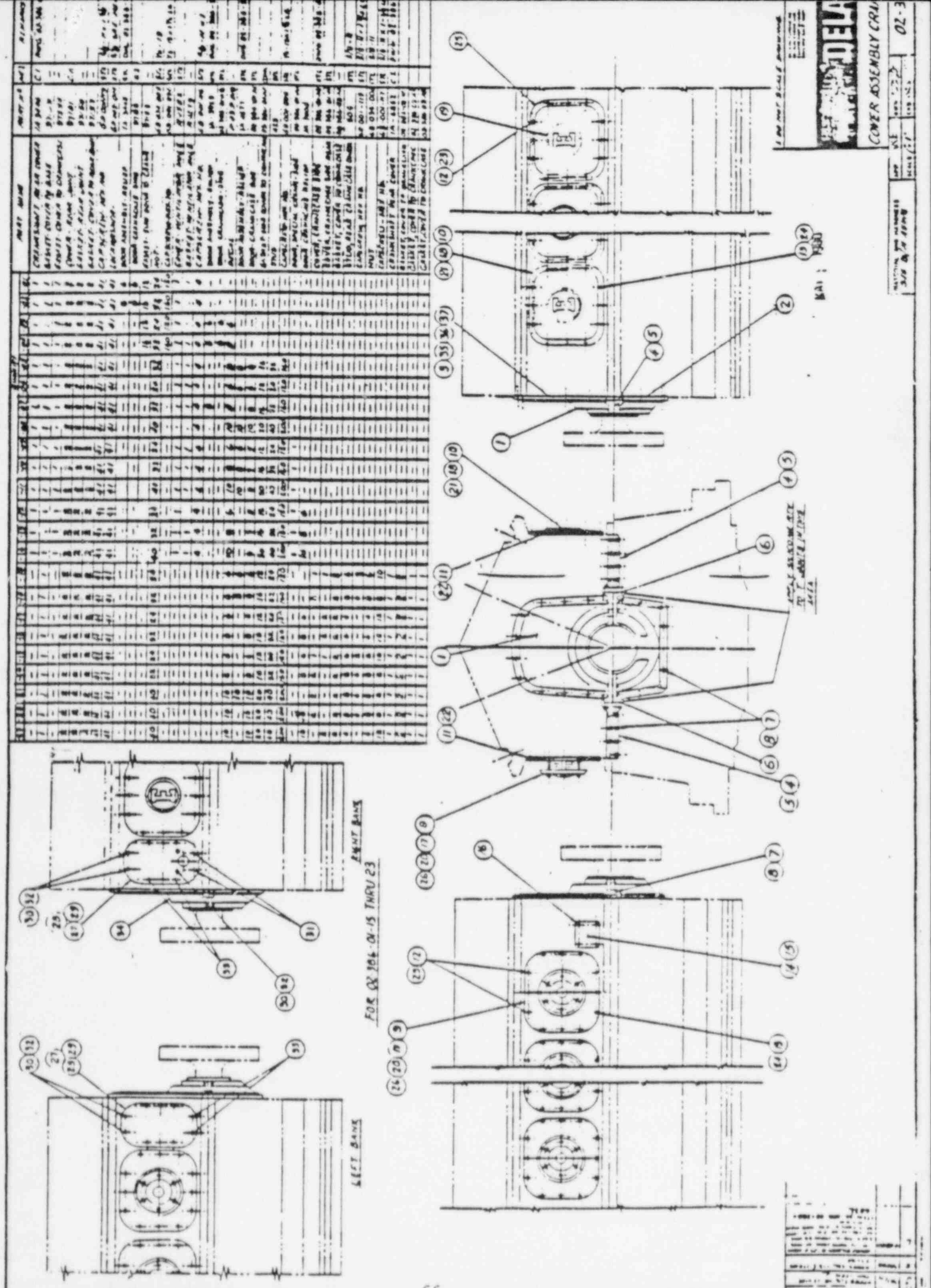
DATE	SUMP TANK TEMP	THRUST CLEARANCE	SIGNATURE

Record readings in plus (+) or minus (–) thousandths of an inch. Example: +0.003 in. write as +3. Write – 0.002 in. as –2, etc.

POSITION	CYLINDER NUMBER STARTING AT GEARCASE END										
	1	2	3	4	5	6	7	8	9	10	DATE
											
											
											
											
											

TDI # 02-386B -- SUMMARY

Part Name:	Crank Case Covers
Examination Area:	N/A
Examination:	Visual

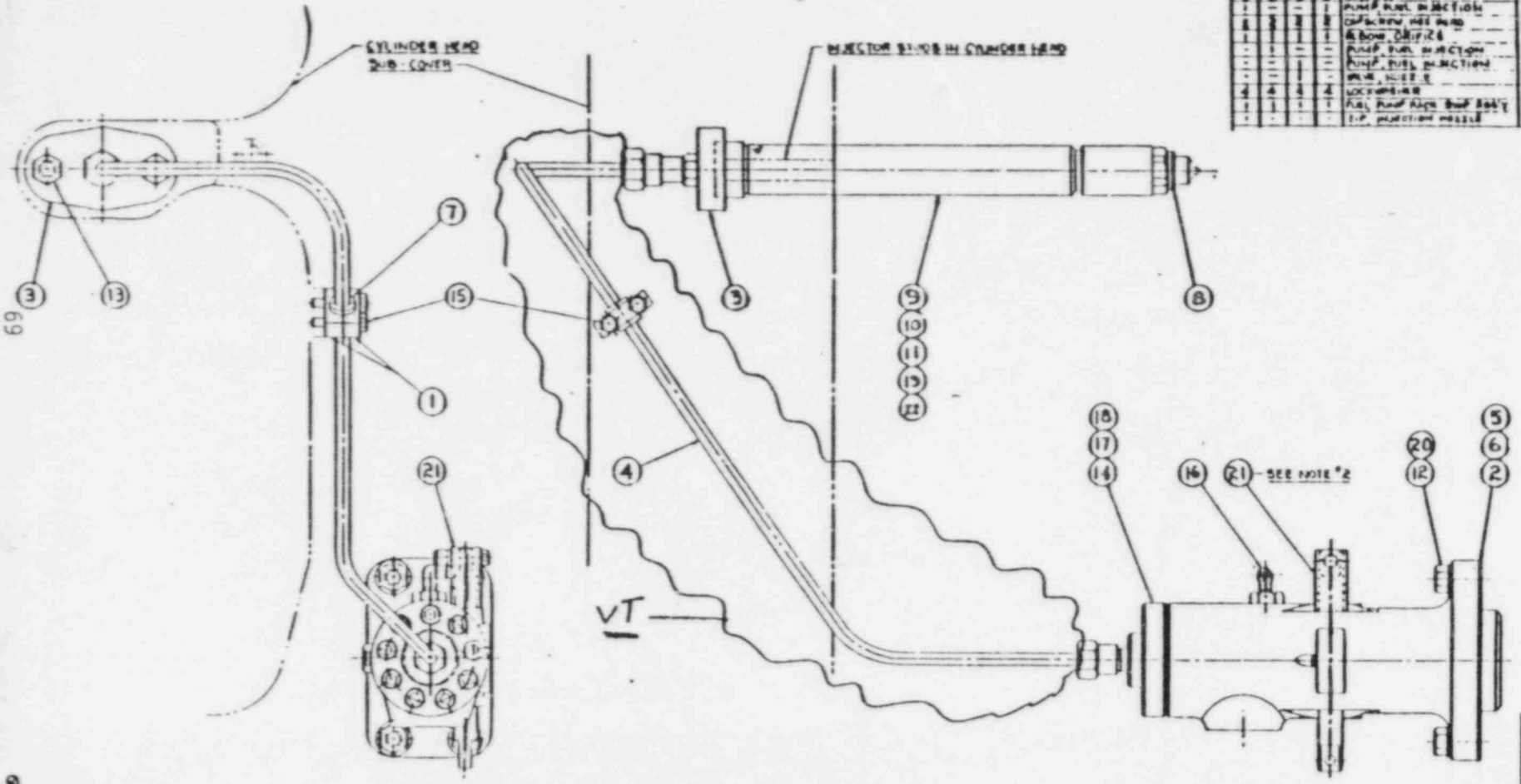

COVER ASSEMBLY CRA
LEFT BANK
RIGHT BANK

Component:	Crank Case Covers
Examination:	Visual, procedure M-VE-1, Rev. 1.
Examination Area:	Right and left bank covers.
Acceptance Criteria:	The following are unacceptable:

- Loose parts.
- Debris.
- Integrity loss at bolts.
- Abnormal leakage.

TDI # 02-365C - SUMMARY

Part Name:	Fuel Oil Injection Tube
Examination Area:	Tube Surface
Examination:	Visual



QTY				PART NAME	PART NO	MAT'L	REMARKS
6	12	2	8			STL	
1	1	1	1			STL	
1	1	1	1			STL	
1	1	1	1			STL	
1	1	1	1			STL	
1	1	1	1			STL	
1	1	1	1			ALUM	
1	1	1	1			COPPER	
1	1	1	1			COPPER	
1	1	1	1			CAST	
1	1	1	1			CAST	
6	12	2	8			STL	
6	12	2	8			STL	
1	1	1	1			CAST	
6	12	2	8			STL	
1	1	1	1			STL	
1	1	1	1			STL	
1	1	1	1			STL	
6	12	2	8			STL	
1	1	1	1			STL	

69

2 FOR INSTALLATION INSTRUCTIONS ON FUEL PUMP REFER TO SEE DRAWING 02-369-934

1 DO NOT SCALE DRAWING

REVISIONS

FUEL INJECTION EQUIPMENT

MATERIAL AND HARDNESS SEE BOM ABOVE

APP'D

DRN

CHK

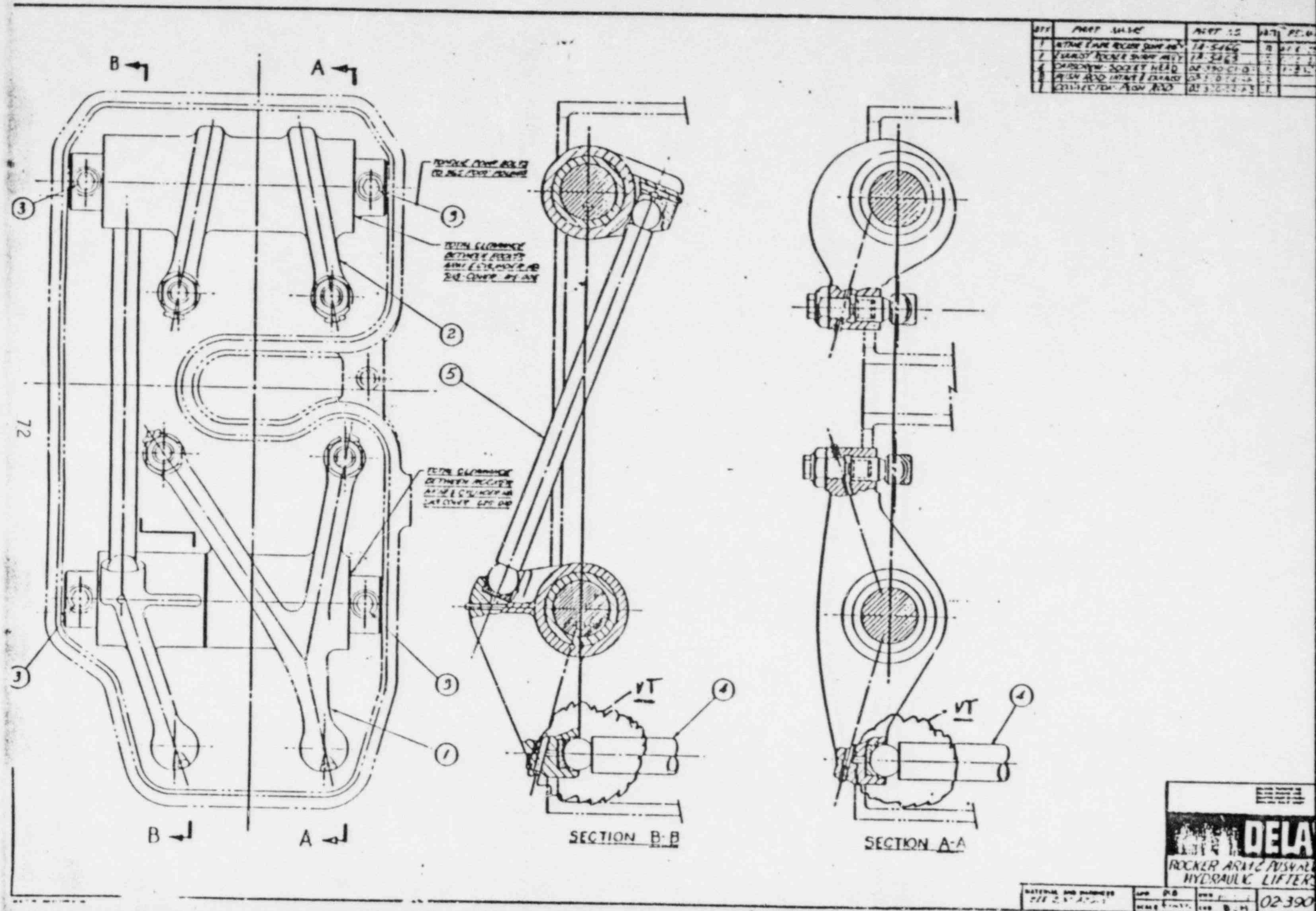
02-365

Component:	Fuel Oil Injection Tube
Examination:	Visual, procedure M-VE-1, Rev. 1
Examination Area:	Complete length of injection tube
Acceptance Criteria:	The following are unacceptable:

- o Seams and cracks.
- o Seam welded tubing.

TDI # 02-390C - SUMMARY

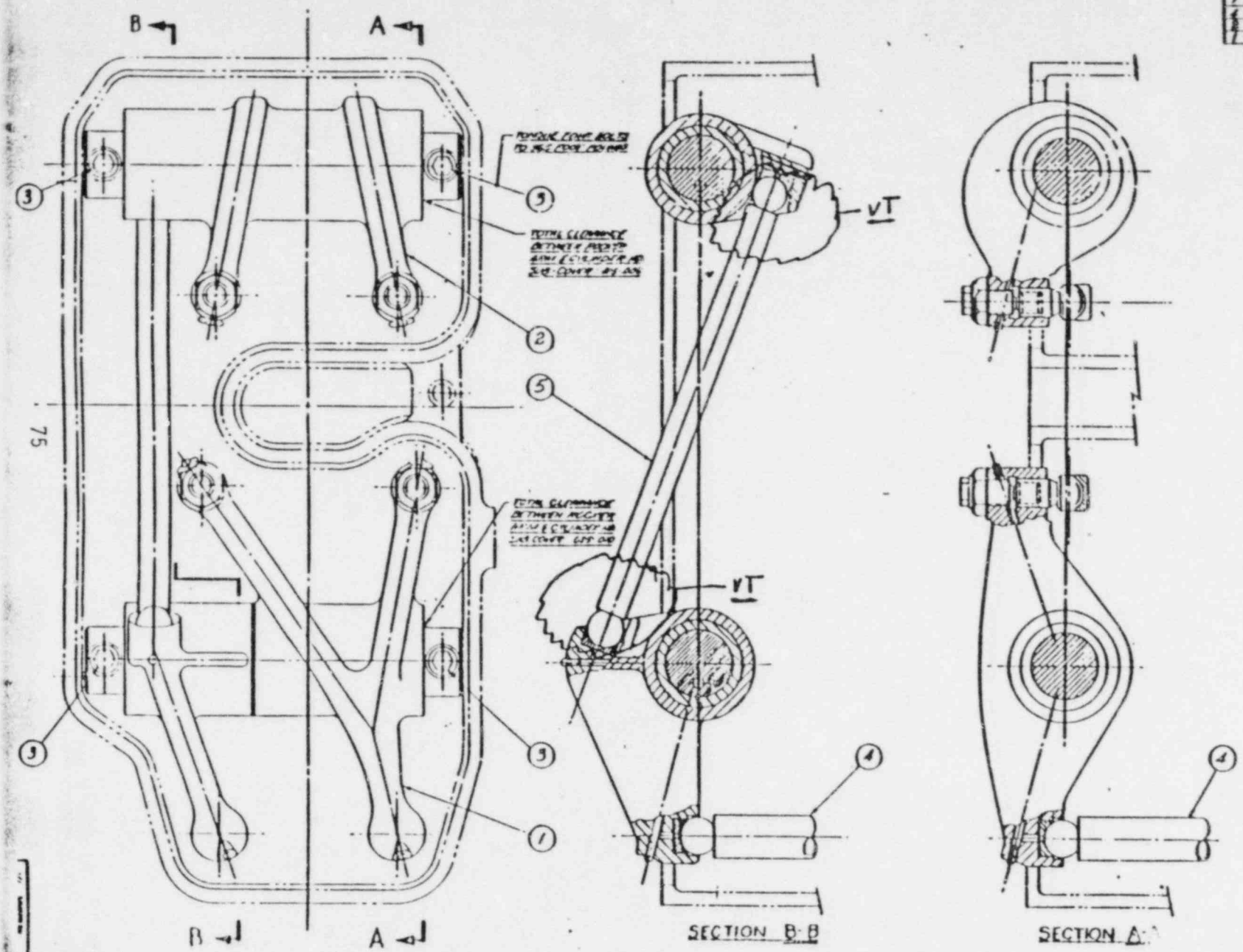
Part Name:	Intake/Exhaust Push Rods
Examination Area:	Friction Weld.
Examination:	Visual
	Liquid Penetrant


PART NAME
SOCKET HEAD
A
B
SECTION B-B
SECTION A-A
VT
1
2
3
4
5
ROCKER ARM & PUSHROD
HYDRAULIC LIFTERS

Component:	Intake/Exhaust Push Rods
Examination:	Visual, procedure M-VE-1, Rev. 1.
Examination Area:	Friction Welds
Acceptance Criteria:	The following are unacceptable: o Cracks.
Examination:	Liquid Penetrant, Procedure M-PT-SR-1,2, Rev. 2.
Examination Area:	Friction weld and wear surface or plug.
Acceptance Criteria:	No cracks.

TDI # 02-390D - SUMMARY

Part Name:	Connector Push Rods
Examination Area:	Friction Weld
Examination:	Visual
	Liquid Penetrant



QTY	PART NAME	PART NO	MAT'L	REMARKS
1	ROCKER ARM & PUSH ROD ASSY	14-5466		
2	EXHAUST ROCKER SHAFT ASSY	14-5463		
4	SOCKET HEAD CAP SCREW	3/8"-16 x 1"		
8	FLAT WASHER	3/8"		
1	ADJUSTER ASSY	14-5464		

DEL

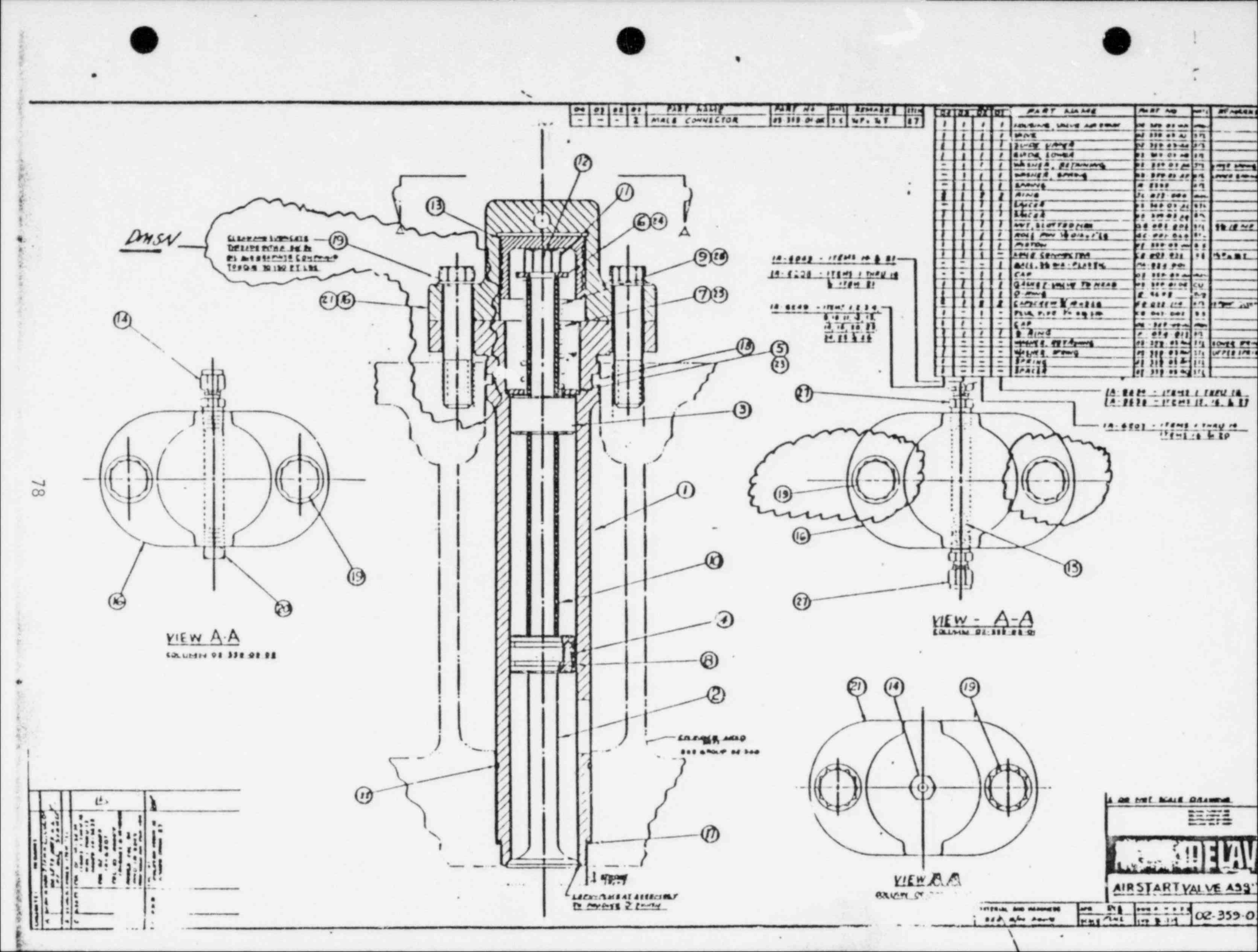
ROCKER ARM & PUSH
HYDRAULIC LIFTE

02-39

Component:	Connector Push Rods
Examination:	Visual, procedure M-VE-1, Rev. 1
Examination Area:	Friction welds.
Acceptance Criteria:	The following are unacceptable: o Cracks.
Examination:	Liquid Penetrant, Procedure M-PT-SR-1,2, Rev. 2.
Examination Area:	Friction weld and wear surface of plug.
Acceptance Criteria:	No Cracks.

TDI # 02-359 - SUMMARY

Part Name:	Air Start Valve Capscrews
Examination Area:	Capscrews length
Examination:	Dimensional


DMSV
VIEW A-A
VIEW - A-A
VIEW
AIR START VALVE ASS'Y
02-359-0

Component:	Air Start Valve Capscrews
Examination:	Dimensional, procedure N/A.
Examination Area:	Valve capscrew length.
Acceptance Criteria:	o Lengths in excess of 2 3/4 ±1/8 inch.
Examination Area:	Capscrew hole(s) in the cylinder head for the capscrew(s) not meeting the above criteria.
Acceptance Criteria:	o Measure total hole depth, hole must be deep enough to facilitate oversized capscrew without bottoming out.

TDI # 02-355-01-OE - SUMMARY

Part Name:	Idler Gear (Right Bank)
Examination Areas:	Teeth. Wear Surfaces.
Examination:	Visual
	Hardness

Component:	Idler Gear
Examination:	Visual, procedure M-VE-1 Rev. 1.
Examination Areas:	Teeth. Wear Surtaces.
Acceptance Criteria:	Wear patterns that indicate abnormal alignment, or surface discontinuities that exhibit material failure shall be reported to NPE.
Examination:	Brinell Hardness Testing, Equotip Hardness Tester.
Examination Area:	Top surface of 4 gear teeth (0°, 90°, 180°, and 270°).
Acceptance Criteria:	NOTE: 7

DIVISION I/DIVISION II

COMPARISON FOR AS-MANUFACTURED SIMILARITIES

APPENDIX 2

APPENDIX 2

TABLE OF CONTENTS

Component: Cylinder Heads

Part Number: 03-360-03-0F

Time Frame: September 1975 - March 1978

1. Materials:

a. Division I -

The cylinder heads were cast in the TDI foundry in accordance with TDI's Material Specification Nos. 1 and 7, which are equivalent to ASTM A27 Class 65/35 and ASTM A216 Grade WCB, respectively. The material change from Specification No. 1 to Specification No. 7 applies only to one (1) head and was done to improve tensile strength properties. Additionally, two other heads cast to Specification No. 1 differ chemically with Specification No. 1 requirements. However, they meet the chemical properties of Specification No. 7 which exhibits superior physical properties and therefore do not affect similarity. The reported physical properties of all 15 heats, however, exceed the minimum values of all applicable material specifications. Although the chromium content of two heats differs slightly from TDI's Material Specification No. 1, discussions with TDI indicate the effects, if any, would provide for superior physical properties.

b. Division II -

The review of the Division II records identified the same results as Division I, except that for the 14 serial and heat numbers reviewed for Division II, only TDI Material Specification No. 1 applies. Additionally, the reported chemical composition for these cylinder heads meets the requirements of TDI Material Specification No. 1.

2. Drawings:

a. Division I -

Revisions F through V to Drawing 03-360-03-0F were made by TDI during the noted time frame. Each revision was reviewed and was determined not to affect similarity.

b. Division II -

The review of Division II records identified the same results as Division I.

3. Processes:

a. Division I -

Revisions 3 through 20 to Route Sheet 03-360-03-0F were made by TDI during the noted time frame. Each revision was reviewed and was determined not to affect similarity.

The route sheet requires each head to undergo a liquid penetrant examination of valve seats, magnetic particle examination of combustion and shroud sides and a hydrostatic test.

b. Division II -

The review of Division II records identified the same results as Division I.

4. Conclusion:

The CMTRs for the cylinder heads reviewed were determined not to affect similarity of materials. Drawing changes and route sheet changes during the noted time frame were reviewed and were determined not to affect similarity. Each cylinder head underwent the same examinations.

Therefore, the as-manufactured quality of the cylinder heads for Divisions I and II is similar based upon the records reviewed at TDI.

Component: Engine Base Assembly

Part Number: 02-305-05-AA/1A-5199

Time Frame: February 17, 1976 - March, 1977 (Engine Base)
March 1964 - April 1981 (Intermediate Bearing Caps)

1. Material:

a. Division I -

The engine base was cast in the TDI foundry in accordance with TDI's Material Specification No. 83, with heat numbers 405S/409S and corresponds to ASTM A48, Class 40B. A comparison between TDI Specification No. 83 with the CMTR dated February 17, 1976, shows that the materials and physical test results meet TDI's specification requirements for chemical and physical properties.

The engine base assembly also contains an intermediate bearing cap. The bearing cap is forged of AISI C1040 material with 163-202 BHN by Park Drop Forge. This was determined by reviewing TDI Drawing No. R-2229, Rev. A, dated March 1964.

b. Division II -

The review of the Division II records identified the same results as Division I except the CMTR indicates the cast date was April 15, 1976 and the heat numbers were 651S/654S.

2. Drawings:

a. Division I -

Revisions F through K of Engine Base Fabrication Drawing No. 02-305-05-AA, which were the changes that occurred during the period of manufacture were reviewed. These changes do not affect the similarity of the engine bases.

The Bearing Cap Die Forge Drawing No. R-2229, Rev. A, dated March 1964 and Machining Drawing No. 02-305-02-AD, Rev. 0, dated June 1970, are the same revisions of the drawings originally used for purchasing and machining of the bearing caps. Since they have not been changed, they do not affect similarity.

b. Division II -

The review of the Division II records identified the same results as Division I.

3. Processes:

a Division I -

The Route Sheet No. 1A-5199, Rev. 6, for the base and bearing caps was reviewed as were previous revisions. The route sheet changes which were incorporated during the period of manufacture do not affect the similarity of the components.

b. Division II -

The review of the Division II records identified the same results as Division I.

4. Conclusion:

The engine base is cast to the same material specification and the CMTR's were reviewed to determine similarity. Drawing changes for the engine base drawing were reviewed and it was determined that the changes do not affect similarity. No changes have been made to the bearing cap drawings. The changes to the Route Sheets were reviewed and determined not to affect similarity.

Therefore, the as-manufactured quality of the engine base and bearing caps for Divisions I and II are similar based upon records reviewed at TDI.

Component: Rocker Arm Capscrews

Part Number: 02-390-01-0G

Time Frame: September 1973 - August 1975

1. Material:

   a. Division I -

      The rocker arm capscrews are carbon steel, heat treated, with a minimum tensile strength of 160,000 PSI. This was determined by reviewing TDI Purchase Material Specification No. GB-011-150, which specifies the material requirements.

      The capscrews are purchased as finished parts, in accordance with the above purchased material specification.

   b. Division II -

      The review of the Division II records identified the same results as Division I.

2. Drawings:

   a. Division I -

      The current TDI Drawing No. 02-390-01-0G, Rev. A, dated March 6, 1973, was reviewed. No changes have been made to this drawing.

      The above drawing details the dimensional requirements of the capscrews. It also specifies the material requirments by reference to TDI's Purchase Material Specification No. GB-011-150. By using the shipment date of the diesel (February 1977) as an end date for reviewing purchase material specification changes, Revisions A through C were reviewed. These revisions only added additional part numbers to the purchased material specification, therefore, these changes did not affect similarity.

   b. Division II -

      The review of the Division II records identified the same results as Division I, with the following exception:

      The shipment date of the Division II diesel was March 1977 and was used as an end date for reviewing drawing changes. Revisions A through C were reviewed, with the same results as shown above.

3. Processes:

a. Division I -

TDI purchases rocker arm capscrews as standard commercial parts, for stock. A discussion with TDI indicated their subsupplier for this component as Horspool and Romine.

A system review of receiving inspection was performed for a sample time frame of September 1973 through Augus 1975 (prior to the shipment of the Division I engine) and confirmed this subsupplier. This review also showed that TDI performed a sampling inspection of each shipment received of this component.

b. Division II -

The review of the Division II records identified the same results as Division I.

4. Conclusion:

Through the investigation of the rocker arm capscrews, the material type and TDI's subsupplier were determined. All purchase material specification revisions were reviewed and it was determined that these revisions did not affect similarity. The system review of receiving inspection also showed that TDI performed a receipt inspection of each shipment received.

Therefore, the as-manufactured quality of the rocker arm capscrews are similar for Divisions I and II based upon the records reviewed at TDI.

Component: Cylinder Block and Landing Area

Part Number: 02-315-03-AE

Time Frame: April 1976 - March 1977

1. Materials:

a. Division I -

Cylinder block is comprised of two castings - link rod and master rod sides. The link rod section, heat number 927S, serial number S, and the master rod section heat number 671S serial number U, were cast by TDI in June 1976 and April 1976, respectively. The CMTRs reviewed indicate TDI's Material Specification to be number 83, Gray Iron. The corresponding ASTM material specification is A48, Class 40B. The physical property requirement (tensile strength) for both heats exceeds the minimum value of Specification No. 83 as well as A48, Class 40B. The chemical composition of heat number 671S meets both material specification requirements. The chemical composition of heat number 927S, however, differs slightly in that the reported silicon content is 2.02 percent, and the sulfur content is .037 percent. Specification No. 83 provides minimum/maximum values for these two elements, 1.65-1.90 percent and .045- .065 percent, respectively. ASTM A48, however, indicates that chemical composition is subordinate to the physical properties of the casting and does not specify chemical composition. This variance, therefore, does not affect similarity.

TDI Material Specification No. 83 was formally written in July 1980. Discussions with TDI indicate the casting methods and material properties since 1976 were consistent with the current material specification.

Heat numbers and CMTRs for the two castings were obtained through TDI records.

b. Division II -

The review of Division II records identified the same results as Division I except for the following:

1) Link rod side (heat number 619S, serial number M) was cast in April 1976. The reported carbon content is 3.23 percent, and the sulfur content is .044 percent. Specification No. 83 provides minimum/maximum values for these two elements of 3.05-3.20 percent and .046- .065 percent, respectively. As stated above, this does not affect similarity.

2) Master rod side (heat number 899S, serial number P) was cast in June 1976. Material properties meet ASTM A48 and Specification No. 83 requirements.

2. Drawings:

a. Division I -

Revisions J, K, and L to TDI Drawing No. 02-315-03-AE were made by TDI during the noted time frame. Each revision of the cylinder block and landing area drawing was reviewed and was determined not to affect similarity. An additional check was made for revisions to this drawing up to the shipment of Unit 2 diesel engines, and these were also determined not to affect similarity.

b. Division II -

The review of Division II records identified the same results as Division I.

3. Processes:

a. Division I -

Revisions 5, 6, and 7 to Route Sheet No. 02-315-03-AE were made by TDI during the noted time frame. Each revision of the cylinder block and landing area route sheet was reviewed and was determined not to affect similarity.

The cylinder block assembly was hydrostatically tested at 65 PSIG for approximately four hours. The test was performed in September 1976 and was witnessed by our A/E's Supplier Quality Representative (SQR). Results of this test were satisfactory.

b. Division II -

The review of Division II records identified the same results as Division I except:

Cylinder block assembly was hydrostatically tested in October 1976, under the same parameters as Division I, and witnessed by our A/E's SQR. Results were satisfactory.

4. Conclusion:

The cylinder blocks are cast to the same material specification, and CMTRs were reviewed to determine similarity. Drawing changes were reviewed, and no changes occurred which affect the similarity of the component. Changes to the manufacturing process were reviewed and were determined not to affect the similarity of the components. Each cylinder block underwent the same examination.

Therefore, the as-manufactured quality of the cylinder blocks, including the landing area, for Divisions I and II are similar based upon the records reviewed at TDI.

Component: Cylinder Head Studs

Part Number: 03-315-01-0A

Time Frame: Could Not Be Determined

1. Materials:

   a. Division I -

      The cylinder head studs are AISI A4140/A4142, hot rolled steel, heat treatment to Rc 20-30. This was determined by reviewing TDI Drawing No. 03-315-01-0A, which specifies the material requirements.

      The studs are purchased as finished parts, in accordance with the above drawing. The revision of the drawing used to purchase this component could not be determined, however, similarity was not affected as determined in the next section.

   b. Division II -

      The review of the Division II records identified the same results as Division I.

2. Drawings:

   a. Division I -

      The current TDI Drawing No. 03-315-01-0A, Rev. H, dated May 8, 1984, was reviewed. Previous changes to this drawing were unavailable for review; however, discussions with TDI indicated these changes do not affect similarity.

      This drawing specifies the dimensional and material requirements of the studs.

   b. Division II -

      The review of Division II records identified the same results as Division I.

3. Processes:

   a. Division I -

      TDI purchases cylinder head studs as standard commercial parts, for stock. A discussion with TDI indicated their subsupplier for this component was Horspool and Romine.

      A system review of receiving inspection was performed and confirmed that Horspool and Romine was the subsupplier for this component. This review also indicated that TDI performed a sampling inspection of each shipment received.

b. Division II -

The review of Division II records identified the same results as Division I.

4. Conclusions:

Through the investigation of the cylinder head studs, the material type and TDI's sub-supplier were determined. Although the specific drawing revision used to purchase these parts could not be determined, the changes were discussed with TDI, who indicated these changes do not affect similarity. Subsupplier certifications as well as TDI receiving inspection indicated material acceptance to purchasing requirements for each shipment.

Therefore, the as-manufactured quality of the cylinder head studs are similar for Division I and II based upon the records reviewed at TDI.

Component: Cylinder Liners

Part Number: 02-315-02-0G

Time Frame: September 1975 - November 1983

1. Materials:

a. Division I -

The cylinder liners are cast by TDI to Material Specification No. 81, gray iron. The corresponding ASTM material Specification is A48, Class 45B. The TDI foundry checks chemical and physical properties for each heat that is poured. The results are documented and maintained in TDI foundry records. To determine similarity of materials, a sampling of foundry records within the noted time frame was reviewed for conformance with both material specifications. Results were satisfactory.

Three cylinder liners were replaced in 1981. Similarity was not affected as indicated in the next section.

b. Division II -

The review of Division II records identified the same results as in Division I, except that one cylinder liner was replaced in 1981 and one replaced in 1983.

2. Drawings:

a. Division I -

Revisions D through U to TDI Drawing No. 02-315-03-AE were made during the noted time frame. Each revision was reviewed and was determined not to affect similarity. Although Rev. Q added as an alternative to TDI's casting technique, a centrifugal casting method, discussions with TDI's QA manager indicate that centrifugal process has not been used for any nuclear service diesel engine.

TDI Drawing No. 02-315-02-0R, no Rev., (centrifugal casting drawing) was also reviewed. No changes were made to this drawing.

b. Division II -

The review of Division II records identified the same results as in Division I.

3. Processes:

a. Division I -

Revisions 0 through 9 to Route Sheet No. 02-315-02-0G were made by TDI during the noted time frame. Each revision was reviewed and was determined not to effect similarity. The liners were assembled into the cylinder block and were hydrostatically tested at 65 PSIG for approximately four (4) hours. This test was witnessed by our A/E's SQR in September 1976. Results were satisfactory.

b. Division II -

The review of Division II records identified the same results as Division I except:

> The liners were assembled into the cylinder block and were hydrostatically tested at 65 PSIG for approximately four (4) hours. This test was witnessed by our A/E's SQR in October 1976. Results were satisfactory.

4. Conclusion:

The cylinder liners are all cast to the same material specification, and typical heats were reviewed and determined to be similar. Revisions to drawings and processes were reviewed and were determined not to affect component similarity. Each liner underwent the same examinations.

Therefore, the as-manufactured quality of the cylinder liners for Division I and II are similar based upon the records reviewed at TDI.

Component: Turbocharger Bracket Bolting

Part Number: GB-001-120
GB-001-143

Time Frame: Could Not Be Determined

1. Material:

   a. Division I -

      The turbocharger bracket bolts are ASTM A449, SAE Grade 5, heat treated. This was determined by reviewing TDI's Purchase Material Specification Nos. GB-001-120 and GB-001-145, both Rev. A, dated June 17, 1970, which specifies the material requirements.

   b. Division II -

      The review of the Division II records identified the same results as Division I.

2. Drawings:

   a. The current TDI Purchase Material Specification Nos. GB-001-120 and GB-001-143, Rev. A, dated June 17, 1970, were reviewed. No changes have been made to the Purchase Material Specifications since the issuance of Rev. A.

      The Purchase Material Specifications specify the dimensional and material requirements of the bolting.

   b. Division II -

      The review of the Division II records identified the same results as Division I.

3. Processes:

   a. Division I -

      TDI purchases turbocharger bracket bolts as standard commercial parts, for stock. A discussion with TDI indicated there were several subsuppliers of this component. TDI's Receiving Inspection Manual, I.P.-200 dated May 10, 1972, shows a sampling inspection is performed as part of the receiving inspection method.

   b. Division II -

      The review of the Division II records identified the same results as Division I.

4. Conclusion:

Although TDI purchases turbocharger bracket bolting as a commercial part, from a variety of subsuppliers, the purchase material specification specifies the same requirements, regardless of the subsupplier used by TDI, and the purchase material specification has not changed since 1974. Also, the bolting is required to be receipt inspected in accordance with TDI's receiving inspection manual.

Therefore, the as-manufactured quality of the turbocharger bracket bolting for Divisions I and II are similar based upon the records reviewed at TDI.

Component: Connecting Rod Boxes

Part Number: 02-340-05-AE and 02-340-05-AF

Time Frame: March 1974 - June 1976

1. Material:

a. Division I -

The connecting rod boxes consist of two halves, the master connecting rod box and the link rod box, and are classified by TDI as the master rod and connecting rod box assembly. This assembly is shown on TDI Drawing No. 02-340-4780, Rev. G, dated April 2, 1976. The assembly was forged to TDI Forging Specification No. D-4169 by Smith-Clayton Forge, Ltd., (master rod box), heat number LZ4109, and by the Park Drop Forge Division (link rod box) heat number 123124. The TDI Material Specification No. D-4169 requires that the materials meet the requirements of ASTM A668. Additionally, supplemental requirements are imposed to meet: special heat treatment, special physical properties, special marking information, and AISI A4142 chemical properties. A materials test report from Smith-Clayton Forge shows chemical and physical properties for heat number LZ4109 while an American Bureau of Shipping Report verifies the same chemical and physical properties for heat number LZ4109. Additionally, a magnetic particle and ultrasonic test are reported to have been performed satisfactorily. A similar set of documents is available for the link rod box heat number 123124 from the Park Drop Forge Division and the American Bureau of Shipping.

b. Division II -

The connecting boxes for Division II are similar to Division I since the Division II master rod boxes are made from the same heat number, LZ4109, and the link rod boxes are made from the same heat number, 123124.

2. Drawings:

a. Division I -

Since it has been established from the materials review that all the master rod boxes for both divisions were forged from the same heat number LZ4109 to the same forging drawing by the same manufacturer, similarity exists. The same applies to the link rod boxes under heat number 123124, since they were all forged from their respective heat, drawing and manufacturer. The Final Machining Drawing No. 02-340-05-AG, Rev. B, dated May 2, 1975, which applies to both halves of the connecting rod boxes, was reviewed as were the changes that occurred during the period of manufacturing. These changes do not affect the similarity of the components.

Component: Connecting Rod Box Bolts

Part Numbers: 02-340-04-AB (Upper Bolts)
02-340-05-AA (Lower Bolts)
02-340-02-OD (Lower Nuts)

Time Frame: August 1974 - July 1976

1. Material:

a. Division I -

The lower and upper bolts are AISI E4140, hot rolled, normalized heat treatment to Rc 29-32. This was determined by reviewing TDI Drawing Nos. 02-340-04-AB and 02-340-05-AA, which specified the material requirements. The lower nuts are AISI 4140, cold drawn, heat treated to Rc 20-25. This was determined by reviewing TDI Drawing No. 02-340-02-OD, which specifies the material requirements.

The bolts and nuts are purchased as finished parts, in accordance with the above drawings. The revision of the drawings used to purchase these components could not be determined; however, similarity was not affected, as determined in the next section.

b. Division II -

The review of the Division II records identified the same results as Division I.

2. Drawings:

a. Division I -

The current drawing revisions are as follows:

02-340-04-AB, Rev. E, dated January 2, 1976
02-340-05-AA, Rev. B, dated February 11, 1975
02-340-02-OD, Rev. B, dated April 8, 1981

Since the drawing revisions used to purchase these components was unknown, the revisions listed above and their respective change notices were reviewed. These changes were found not to have affected similarity.

The drawings shown above specify the dimensional and material requirements of the respective components.

b. Division II -

The review of the Division II records identified the same results as Division I.

3. Processes:

a. Division I -

TDI purchases the connecting rod box bolts and nuts as standard commercial parts for stock. Discussions with TDI indicated their subsupplier for these components was Horspool and Romine.

A system review of receiving inspection was performed for a sample time frame of August 1974 through July 1976 (prior to the shipment of the Division I engine) and confirmed that Horspool and Romine was the subsupplier. This review also showed that TDI performed either a 100 percent inspection or a sampling inspection of these components for each shipment received. After receiving inspection acceptance, magnetic particle examinations were performed by TDI.

b. Division II -

The review of the Division II records identified the same results as Division I.

4. Conclusion:

The investigation of the connecting rod box bolts determined that the type of material and TDI's subsupplier were the same for all connecting rod box bolts. Although the specific drawing revision used to purchase these parts could not be determined, the changes reviewed did not affect similarity. The system review of receiving inspection also showed that TDI performed a receipt inspection of each shipment received to confirm specification conformance. TDI also performed a magnetic particle examination.

Therefore, the as-manufactured quality of the connecting rod box bolts are similar to Divisions I and II based upon the records reviewed at TDI.

Component: Connecting Rod Bushings (Wrist Pin)

Part Number: R-3195

Time Frame: March 1974 - December 1975

1. Material:

a. Division I -

The connecting rods bushings are ASARCON No. 77, No. 773 bronze or Johnson continuous cast SAE 660 bronze. This was determined by reviewing TDI Drawing No. R-3195, Rev. C, dated December 2, 1970, which specifies the material requirements.

The bushings are purchased as finished parts, in accordance with the above drawing.

One bushing in Division I was replaced in 1981. The revision of the drawing used to purchase this bushing could not be determined; however, similarity was not affected as determined in the next section.

b. Division II -

The review of the Division II records identified the same results as Division I, except that none of the bushings have been replaced.

2. Drawings:

a. Division I -

The current TDI Drawing No. R-3195, Rev. G, dated May 9, 1984, was reviewed as well as the change notices for previous revisions. By using the shipment date of the diesel (February 1977) as an end date for reviewing drawing changes, it was determined that the revision used to purchase the bushings was Rev. C, dated December 2, 1970. Revisions D through G occurred after the shipment of the Division I diesel.

In regard to the one bushing that was replaced in 1981, the two change notices that occurred during this time frame were reviewed. These changes were found not to have affected similarity.

TDI Drawing No. R-3195 specifies the dimensional and material requirements of the bushing.

b. Division II -

The review of the Division II records identified the same results as Division I with the following exceptions:

The shipment date of the Division II diesel was March 1977, and was used as an end date for reviewing drawing changes. Revisions D through G occurred after the shipment of the Division II diesel.

3. Processes:

a. Division I -

TDI purchases connecting rod bushings as standard commercial parts, for stock. A discussion with TDI indicated their subsupplier for this component was Kingwell Brothers.

A system review of receiving inspections was performed for a sample time frame of March 1974 through December 1975 (prior to the shipment of the Division I engine) and confirmed that Kingwell Brothers was the subsupplier. This review also showed that TDI performed either a 100 percent inspection or a sampling inspection of each shipment received of this component.

b. Division II -

The review of the Division II records identified the same results as Division I.

4. Conclusion:

The investigation of the connecting rod bushings (wrist pins), determined that the type of material, the drawing used to purchase this part, and TDI's subsupplier were the same. The system review of receiving inspection also showed that TDI performed a receipt inspection of each shipment received to verify conformance to their drawing.

Therefore, the as-manufactured quality of the connecting rod bushings are similar for Division I and II based upon the records reviewed at TDI.

Component: Connecting Rod Bearing Shells (Upper and Lower)

Part Number: 02-340-04-AG

Time Frame: April 1978 - April 1983

1. Materials:

   a. Division I -

      The materials for the shells is purchased from ALCOA and is an aluminum alloy, permanent mold casting, ALCOA Specification No. 852-T5. The shell sections are identified by lot number.

      The currently installed shells are replacements and were cast within the noted time frame. MP&L provided lot numbers and journal locations for both divisions.

      The material test reports for five lot numbers were compared to the chemical and physical requirements of the ALCOA Specification. The materials were found to meet the requirements of the specification and were found to be similar.

   b. Division II -

      The review of Division II records identified the same results as Division I except:

         Six bearing shells were manufactured in 1983 and were cast to ALCOA Specification No. 852-T5. The remaining connecting rod bearing shells were manufactured in April and May, 1978, and were cast to ALCOA Specification No. B-750-T5 or B-850-T5. This specification number change did not affect the chemical and physical property requirements of the specification. The comparison of the material test reports for five lot numbers were compared with the material specification and found to meet the chemical and physical requirements.

2. Drawings:

   a. Division I -

      TDI Drawing Nos. 02-340-04-AG, Rev. G dated June 21, 1977 and Rev. H, dated June 15, 1982 were used during the manufacturing period for this part. The drawing specifies the type of material. The drawings were reviewed for changes that occurred during the noted time frame. It was determined that these changes do not affect similarity.

   b. Division II -

      The review of Division II records identified the same results as Division I.

3. Processes:

a. Division 1 -

Revisions 10 through 17 of Route Sheet No. 02-340-04-AG, were reviewed tor the noted time frame. It was determined that these changes do not affect similarity.

b. Division 1I -

The review of Division II records indentified the same results as Division I except for the following:

4. Conclusions:

The material test reports were compared and found to be similar and meet the ALCOA specification requirements. The drawing revisions and route sheet changes were reviewed and found not to affect similarity.

Therfore, the as-manufactured quality of the connecting rod bearing shells for Divisions I and II are similar based upon the records reviewed at TDI.

Component: Piston Crowns

Part Number: 03-340-04-AE

Time Frame: December 1975 - June 1978

1. Material:

   a. Division I -

      The CMTRs indicate the material was cast by TDI on various dates from December 1975 to March 1978 to TDI Material Specification No. 15, grade 90/60, medium carbon, low alloy steel. The corresponding ASTM material specification is A148, grade 90/60. Material certifications were reviewed through TDI records. CMTRs reviewed for the ten heat numbers meet the physical and chemical properties of ASTM A148, grade 90/60 as well as the physical property requirements of Specification No. 15, Revisions 4 and 5. Although the reported chemical composition for three heats differ slightly from Specification No. 15, ASTM A148 indicates that the chemical composition is subordinate to physical properties. This has been determined not to affect similarity.

      Although earlier revisions to TDI Specification No. 15 prior to February 1976 were not available for review, discussion with TDI's chief metallurgist indicates the changes were minor and do not effect similarity.

   b. Division II -

      Same as Division I, except that for the CMTRs for twelve crowns reviewed, two heats differed slightly in their chemical composition from Specification No. 15. As noted above, this does not affect similarity.

      The casting dates range from December 1975 to October 1976.

2. Drawings:

   a. Division I -

      Revisions F, G and H to TDI Drawing No. 03-340-04-AE were reviewed for changes that occurred during the noted time frame. Each revision was reviewed and was determined that the changes do not affect the similarity of the components. The time frame in which these drawing changes were made also include the Unit 2 engines.

   b. Division II -

      The review of the Division II records identified the same results as Division I.

3. Processes:

a. Division I -

Revisions 4 through 9 to Route sheet No. 03-340-04-AE were reviewed for changes that occurred during the noted time frame. Each revision was reviewed and it was determined not to affect the similarity of components.

Each crown underwent a magnetic particle and ultrasonic examination.

b. Division II -

The review of the Division II records identified the same results as Division I.

4. Conclusion:

Slight differences in the reported chemical composition with TDI Material Specification No. 15 have been determined not to affect material similarity. All applicable revisions to TDI's detail drawing and route sheet were reviewed and it was determined that these changes do not affect similarity. Each crown underwent the same examinations.

Therefore, the as-manufactured quality of the piston crowns for Divisions I and II is similar based upon the records reviewed at TDI.

Component: Piston Skirts

Part Number: 03-341-C4-AE

Time Frame: June 1983 - January 1984

1. Material:

   a. Division I -

      The CMTRs indicate that the piston skirts, involving four heats, were cast by TDI on August 1983 and September 1983 to Material Specification No. 93, Grade 100/70/03 - nodular iron. The corresponding ASTM, Material Specification is A536, Grade 100/70/03. CMTRs reviewed for these heat numbers meet the physical property requirements of ASTM A536, Grade 100/70/03 and Specification No. 93, Grade 100/70/03, Rev. 4. Although the reported chemical composition of two of these heats differs slightly from TDI Specification No. 93, ASTM A536, Paragraph 4, indicates that the chemical composition is subordinate to physical properties. This has been determined not to affect similarity.

      All piston skirts were cast to TDI Material Specification No. 93, Rev. 4, dated October 10, 1981.

      Serial and heat numbers and the location of piston skirts on the diesel engines were obtained through TDI records as well as from information provided by MP&L.

   b. Division II -

      The review of the Division II records identified the same results as Division I, except that 9 heats are involved and the chemical composition of three heats differs slightly from TDI Specification No. 93. As noted above, this does not affect similarity.

2. Drawings:

   a. Division I -

      The drawing utilized to manufacture this item was TDI Drawing No. 03-341-04-AE, Rev. E. No changes were made to this drawing during the noted time frame.

   b. Division II -

      The review of the Division II records identified the same results as Division I.

3. Processes:

a. Division I -

The route sheet utilized to produce this item was 03-341-04-AE, Rev. 11. No changes were made to this route sheet during the noted time frame. Route sheets used during the manufacturing of the piston skirts were reviewed and found to be satisfactory.

Each piston skirt underwent a magnetic particle examination.

b. Division II -

The review of the Division II records identified the same results as Division I.

4. Conclusions:

Serial and heat numbers and locations, as well as CMTRs for each piston skirt, were available and reviewed. Slight differences in the reported chemical composition do not affect similarity. Since these skirts are recent replacements, the same detail drawing and route sheet was used by TDI during manufacturing. Each skirt underwent the same examinations.

Therefore, the as-manufactured quality of the piston skirts for Divisions I and II are similar based upon the records reviewed at TDI.

Component: Piston Studs

Part Number: 03-341-04-0B

Time Frame: October 1983

1. Materials:

   a. Division I -

      The piston studs are AISI 4140, steel, normalized heat treatment to Rc 25-30. This was determined by reviewing TDI Drawing No. 03-341-04-AB, no revision, dated August 2, 1982, which specifies the material requirements.

      The studs are purchased as finished parts, in accordance with the above drawing.

      The original piston studs were replaced in late 1983, in accordance with the above drawing.

   b. Division II -

      The review of Division II records identified the same results as Division I, including the replacement of the original piston studs in late 1983.

2. Drawings:

   a. Division I -

      The current TDI Drawing No. 03-341-04-AB, no revision, dated August 3, 1982, was reviewed. The above drawing specifies the dimension and material requirements of the piston studs. There have been no revisions made to this drawing, since the issuance date, and all studs have been made to this same revision.

   b. Division II -

      The review of Division II records identified the same results as Division I.

3. Processes:

   a. Division I -

      TDI purchases piston studs as standard commercial parts, for stock. A discussion with TDI indicated their subsupplier for this component was Horspool and Romine.

A system review of receiving inspection was performed for a sample time frame of October 1983 (prior to the shipment of the replacement studs) and confirmed that Horspool and Romine was the subsupplier. This review also showed that TDI performed either a 100 percent inspection or a sampling inspection of each shipment received of this component. After receiving inspection acceptance, magnetic particle examinations were performed by TDI.

b. Division II -

The review of Division II records identified the same results as Division I.

4. Conclusions:

The investigation of the piston studs determined the material type, the drawing used for purchase, and TDI's subsupplier, were the same. The system review of receiving inspection also showed that TDI performed a receipt inspection of each shipment received and a magnetic particle examination.

Therefore, the as-manufactured quality of the piston studs for Division I and II are similar based upon the records reviewed at TDI.

Component: Crankshaft

Part Number: 02-310-08-AE

Time Frame: June 1975 - March 1977

1. Materials:

   a. Division I -

      The crankshaft was forged and rough machined by Elwood City Forge Corp. to TDI's Drawing No. 02-310-08-AC, Rev. A, and Design Specification No. D-4774. The drawing provides dimensions and Specification No. D-4774 provides material requirements, corresponding to ASTM A668E for physicals and AISI C1040 for chemicals.

      The CMTR indicates the forging date is June 1975, and the heat number is 51225-1.

   b. Division II -

      The review of Division II records identified the same results as in Division I except for the following:

      1) The crankshaft was forged and final machined by National Forge Company.

      2) The CMTR indicates the heat number is 125780. The forging date is June 1976.

      3) CMTR indicates an ultrasonic examination to ASTM A503 and a magnetic particle examination to ASTM A456 was performed. Results indicate there were no reportable indications.

2. Drawings:

   a. Division I -

      The crankshaft was forged and final machined by TDI to Drawing No. 02-310-08-AA, Rev. C, dated January 1976. A review of the drawing changes showed that Rev. C increased the bearing journal oil hole radius from a 3/16" radius to 7/16" radius.

   b. Division II -

      The crankshaft was forged and final machined by the National Forge Company to TDI Drawing No. 02-310-08-AA, Rev. B, dated February 1975.

3. Processes:

a. Division I -

Revisions 0 through 7 to Route Sheet No. 02-310-08-AE were reviewed and found not to affect similarity.

TDI performed a magnetic particle and ultrasonic examination as well as a final inspection on January 1976 for dimensions and surface finish. A supplementary check for chemical composition and etching was performed by TDI.

b. Division II -

The review of Division II records identified the same results as in Division I except that final inspection was performed on September 1976.

4. Conclusions:

The crankshafts were forged to the same material specification and drawing. The final machining drawing, Rev. C, increased the journal oil hole radius from 3/16" to 7/16". This revision occurred during the fabrication time frame for the crankshafts. The recent disassembly inspection of the Division I engines confirmed that the 7/16" journal oil hole radius exists for this crankshaft. However, for the Division II crankshaft it could not be confirmed through a review of TDI records if the 7/16" radius existed. However, this does not affect similarity based upon the conclusions of a report by the TDI Diesel Generator Owner's Group. This report dated, May 22, 1984, concluded that the oil hole radius contributes little to the stress concentration factors. The largest contribution to stress is from engine operation near critical frequencies. Therefore, since the oil hole diameter has little effect upon stress concentration in the crankshaft and the Grand Gulf engines do not operate near a critical frequency, the journal oil hole radius difference does not affect similarity.

A review of the process changes that occurred during the time frame were determined not to affect similarity.

Therefore, the as-manufactured quality of the crankshafts are similar for Divisions I and II based upon the records reviewed at TDI.

Component: Crankcase Covers: Gaskets & Bolting

Part Numbers: 02-386-01-AA/97159 (Gasket)
02-386-01-AA/97254 (Gasket)
02-386-01-AA/GB-001-119 (Bolts)

Time Frame: Could Not Be Determined

1. Material:

a. Division I -

The gaskets are Raybestos Manhatten K-68. This was determined by reviewing Drawing Nos. 97159, no revision, dated August 2, 1954, and 97254, which specify the material requirements. The bolts are ASTM A449, SAE Grade 5, heat treated. This was determined by reviewing TDI Purchase Material Specification No. GB-001-119, Rev. A, dated June 17, 1970.

The gaskets and bolts are purchased as finished parts in accordance with the above drawings and the purchased material specification.

The revision of TDI Drawing No. 97254 used to purchase the gasket could not be determined; however, similarity was not affected as determined in the next section.

b. Division II -

The review of the Division II records identified the same results as Division I.

2. Drawings:

a. Division I -

The current revisions were reviewed as follows:

TDI Drawing No. 97159, no revision, dated August 2, 1954
TDI Drawing No. 97254, Rev. C, dated August 4, 1978
TDI Purchase Material Specification No. GB-001-119, Rev. A, dated June 17, 1970

No changes have been made to TDI Drawing No. 97159 and TDI Purchase Material Specification No. GB-001-119 since their respective issuance dates shown above and, therefore do not affect component similarity. The current revision and the previous revisions of TDI Drawing No. 97254 were reviewed. These changes were found not to have affected similarity.

The drawings and purchase material specification, shown above, specify the dimensions and material requirements of the respective component.

b. Division II -

The review of the Division II records identified the same results as Division I.

3. Processes:

a. Division I -

TDI purchases the crankcase cover gaskets and bolting as standard commercial parts, for stock. A discussion with TDI indicated there were several subsuppliers of these components. TDI's Receiving Inspection Manual, I.P.-200, dated May 10, 1972 shows a sampling inspection is performed as part of the receiving inspection method.

b. Division II -

The review of the Division II records identified the same results as Division I.

4. Conclusion:

Although TDI purchases the crankcase cover gaskets and bolts as a commercial part, from a variety of subsuppliers, the drawings and the purchase material specification specify the same requirements, regardless of the subsupplier used by TDI. Also, these components are required to be receipt inspected in accordance with TDI's Receiving Inspection Manual.

Therefore, the as-manufactured quality of the crankcase cover gaskets and bolts are similar for Divisions I and II based upon the records reviewed at TDI.

Component: Fuel Oil Injection Tubes

Part Number: 1A-2600

Time Frame: October 1972 - May 1984

1. Material:

   a. Division I -

      The fuel oil injection tubes are cold drawn seamless steel, either SAE 1008 or SAE 1010, with a minimum tensile strength requirement of 45,000 PSI, in accordance with TDI Design Specification No. D266.

      The tubing is purchased in bulk quantity, fittings are added and the tubing is bent to shape in TDI's facility to obtain the finished product.

      One of the original fuel oil injection tubes was replaced in 1983.

   b. Division II -

      The review of the Division II records identified the same results as Division I, including the replacement of one of the original fuel oil injection tubes in 1983.

2. Drawings:

   a. Division I -

      The current Drawing No. 02-365-01-0A, Rev. A, dated February 6, 1968, was reviewed. This drawing details the dimensional requirements of the tubes. It also specifies the material requirements by reference to TDI Design Specification No. D266. There have been no changes made to this drawing.

      The current TDI Design Specification No. D266, Rev. C, dated May 7, 1984, was reviewed, as well as previous revisions. The specification was issued October 1972 with Rev. A occurring in July 1978, well after the ship date of both divisions. This would indicate that the original tubes were purchased to the same specification. The design specification changes, Rev. A and B, which affect the tubes replaced in 1983, were reviewed. The changes were found not to affect similarity.

   b. Division II -

      The review of the Division II records identified the same results as Division I.

3. Processes:

a. Division I -

TDI purchases tubing as standard commercial parts, for stock.

Route sheet, 1A-2600, Rev. 1, was reviewed for process changes that occurred prior to the shipment of this engine. One revision to the route sheet occurred in 1981; however, this revision did not affect the similarity of original, nor did it affect the similarity of the tube that was replaced in 1983.

b. Division II -

The review of the Division II records identified the same results as Division I.

4. Conclusion:

The fuel oil injection tubes are all original equipment except one tube which was replaced on each division in 1983. The original tubes were purchased to the same design specification. Althougn the tubes replaced in 1983 were purchased to subsequent revisions, it was determined that changes to the specification do not affect similarity. The tubes were manufactured to the same drawing, and only one change to the route sheet occurred which did not affect similarity.

Therefore, the as-manufactured quality of the fuel oil injection tubes are similar to Divisions I and II based upon the records reviewed at TDI.

Component: Push Rod, Intake and Exhaust

Part Number: 02-390-06-AB

Time Frame: January 1984 - February 1984

1. Material:

   a. Division I -

      The intake and exhaust push rods consist of a length of pipe with friction welded plugs attached to both ends and have identical configurations. The push rods were manufactured by Weber Machine, Inc. The pipe is ASTM A106B, heat number M43728, and the plug is AISI E8740, heat number 51266. The push rod ends are induction hardened at 1500°F, glycol quenched, and tempered at 300°F for one hour. The recorded hardness is Rc 55-60.

      The heat numbers and CMTRs were provided by Weber Machine, Inc., to TDI.

   b. Division II -

      The review of Division II records identified the same results as Division I.

2. Drawings:

   a. Division I -

      The procurement drawing issued to Weber Machine, Inc., by TDI to manufacture this item was 02-390-06-AB, Rev. A, dated November 22, 1983. No changes were made to this drawing during the manufacturing of this part.

   b. Division II -

      The review of Division II records identified the same results as Division I.

3. Process:

   a. Division I -

      TDI purchased this part from Weber Machine, Inc. The welds underwent a radiographic and magnetic particle examination prior to shipment to TDI.

      TDI also performed a magnetic particle examination on each part and had a supplementary hardness check performed by Signet Testing Laboratories.

Dates for the time frame were obtained from Weber Machine, Inc., and TDI records.

b. Division II -

The review of Division II records identified the same results as in Division I.

4. Conclusion:

The intake and exhaust push rods are a new design and have recently been installed in both divisions. The review shows that all the push rods were made from the same heats by the same manufcturer, manufactured to the same drawings, and have undergone the same series of examinations.

Therefore, the as-manufactured quality of the intake and exhaust push rods for Divisions I and II are similar based upon the records reviewed at TDI.

Component: Push Rod, Connector

Part Number: 02-390-07-AG

Time Frame: December 1983 - January 1984

1. Material:

   a. Division I -

      The connector push rod consists of a length of pipe with friction welded plugs attached to both ends. The push rods were manufactured by Weber Machine, Inc. The pipe is ASTM A106B, heat number M43728, and the plug is AISI E8740, heat number 8081329. The push rod ends are induction hardened at 1500°F, glycol quenched, and tempered at 300°F for one hour. The recorded hardness is Rc 55-60.

      The heat numbers and CMTRs were provided by Weber Machine, Inc., to TDI.

   b. Division II -

      The review of Division II records identified the same results as Division I.

2. Drawings:

   a. Division I -

      The procurement drawing issued to Weber Machine, Inc., by TDI to manufcture this item was 02-390-07-AG, Rev. A. No changes were made to this drawing during the manufacturing of this part.

   b. Division II -

      The review of Division II records identified the same results as Division I.

3. Process:

   a. Division I -

      TDI purchased this part from Weber Machine, Inc. The welds underwent a radiographic and magnetic particle examination prior to shipment to TDI.

      TDI also performed a magnetic particle examination on each part and had a supplementary hardness check performed by Signet Testing Laboratories.

      Dates for the time frame were obtained from Weber Machine, Inc., and TDI records.

b. Division II -

The review of Division II records identified the same results as Division I.

4. Conclusion:

The connector push rods are a new design and have recently been installed in both divisions. The review shows that all the push rods were made from the same heats by the same manufacturer, manufactured to the same drawings, and have undergone the same series of examinations.

Therefore, the as-manufactured quality of the connector push rods for Divisions I and II are similar based upon the records reviewed at TDI.

Component: Air Start Valve Capscrews

Part Number: GB-032-114

Time Frame: Could Not Be Determined

1. Material:

   a. Division I -

      The air start valve capscrews are ASTM A449, SAE Grade 5, heat treated. This was determined through Purchase Material Specification No. GB-032-114, Revision A, dated February 4, 1974, which specifies the material requirements.

      The capscrews are purchased as finished parts, in accordance with the above purchase material specification.

   b. Division II -

      The review of the Division II records identified the same results as Division I.

2. Drawings:

   a. Division I -

      The current Purchased Material Specification No. GB-032-114, Rev. A, dated February 4, 1974, was reviewed. The purchase material specification specifies the dimensional and material requirements of the capscrews. No changes have been made to this purchased material specification since the issuance of Rev. A.

   b. Division II -

      The review of the Division II records identified the same results as Division I.

3. Process:

   a. Division I -

      TDI purchases air start valve capscrews as standard commercial parts, for stock. A discussion with TDI's Quality Engineering Manager indicated there are several subsuppliers of this component. TDI's Receiving Inspection Manual, I.P.-200, dated May 10, 1972, shows that a sampling inspection is performed as part of the receiving inspection method.

b. Division II -

The review of the Division II records identified the same results as Division I.

4. Conclusion:

Although TDI purchases air start valve capscrews as a commercial part, from a variety of subsuppliers, the purchase material specification specifies the same requirements regardless of the subsupplier used by TDI, and the purchase material specification has not changed since 1974. Also, the capscrews are required to be receipt inspected in accordance with TDI's receiving inspection manual.

Therefore, the as-manufactured quality of the air start valve capscrews for Division I and II are similar based upon the records reviewed at TDI.

Component: Turbocharger

Part Number: MP-022-000 (Right Bank)
MP-023-000 (Left Bank)

Time Frame: August 1975 - June 1977

1. Material:

a. Divsion I -

The turbochargers are purchased as a completed assembly from Elliot Company, who has the responsibility for the material selection.

b. Division II -

The review of the Division II records identified the same results as Division I.

2. Drawings:

a. Division I -

The current TDI Purchase Material Specification Nos. MP-022-000, and MP-023-000, both Rev. B, dated March 24, 1976, were reviewed as well as the change notices for previous revisions. Since the Unit 2, Divisions I and II, turbochargers are installed on Unit 1 Divisions I and II diesels, the shipment date of the Unit 2 turbochargers (March 1978) was used as an end date in reviewing purchase material specification changes. In reviewing these changes, it was determined that they do not affect the similarity of these components.

The Purchase Material Specification for the turbochargers specifies the performance characteristics of the engine such as model number, type, and rating. The specification describes the turbocharger by listing details such as model number, number of turbochargers required per engine and the requirements for the turbocharger's compressor and turbine sections. TDI's subsupplier, Elliot Company, then designs a turbocharger to meet these requirements.

b. Division II -

The review of the Division II records identified the same results as Division I.

3. Processes:

a. Division I -

TDI purchases turbochargers as standard commercial parts, for stock. TDI's purchase material specification specifies an Elliot Company

model number. This data was confirmed by a review of an Elliot Company catalog and a discussion with TDI.

A system review of receiving inspection was performed for a sample time frame of August 1975 through June 1977 (prior to the shipment of the Unit 2 engines) and confirmed that the Elliot Company was the subsupplier. This review also showed that TDI receipt inspected all turbochargers received from Elliot Company.

b. Division II -

The review of the Division II records identified the same results as Division I.

4. Conclusion:

Essentially, the turbochargers are purchased by TDI as a catalog part from Elliot Company. Although changes were made to TDI's purchase material specification, there is no impact to similarity. The purchase material specification specifies identical requirements for the turbocharger. Receipt inspection is also performed by TDI for each turbocharger received.

Therefore, the as-manufactured quality of the turbochargers for Divisions I and II are similar based upon the records reviewed at TDI.